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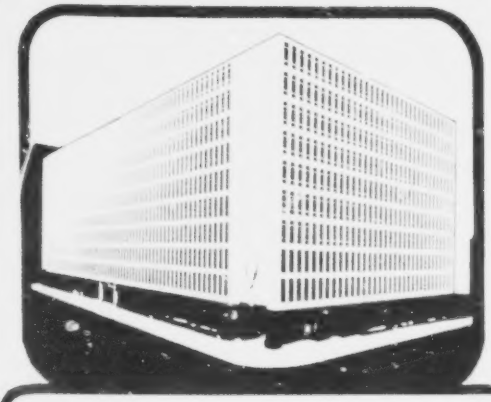

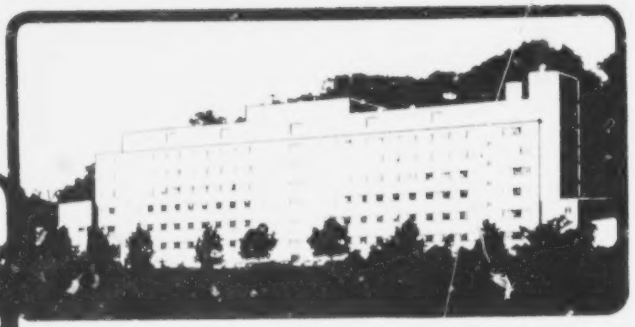

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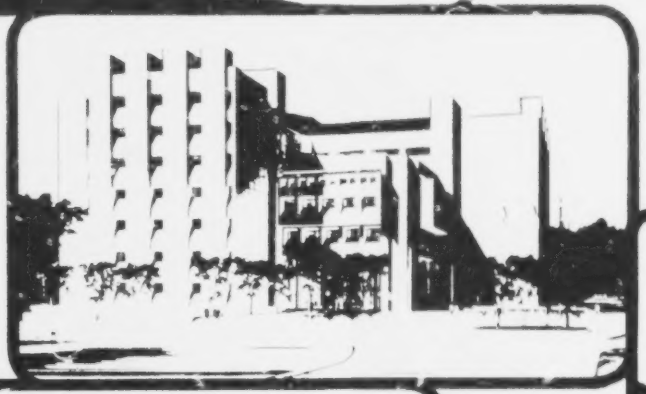

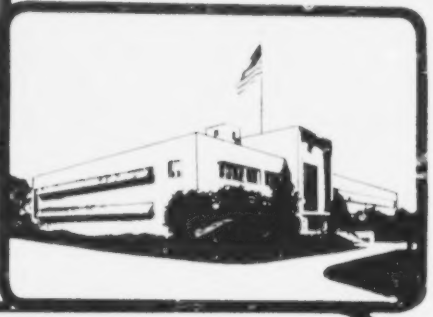

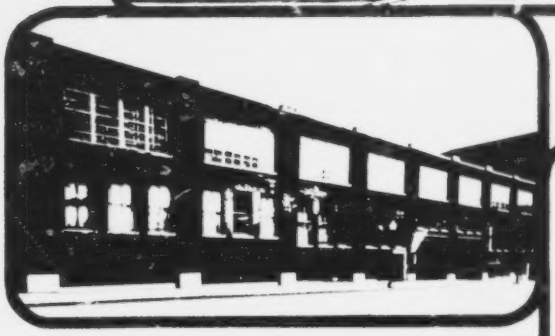

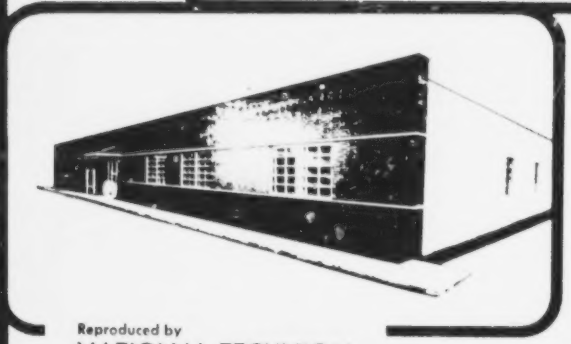

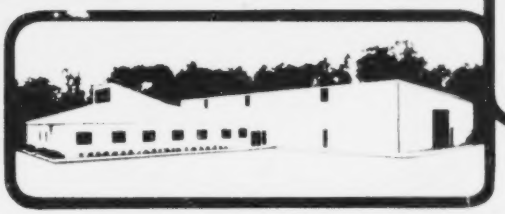

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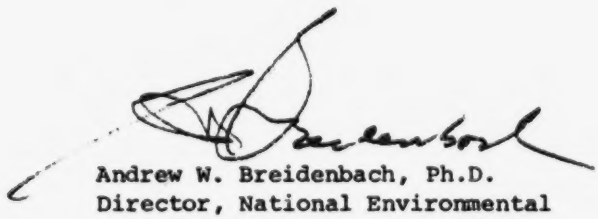
The National Environmental Research Center, Cincinnati, U.S. Environmental Protection Agency, has reviewed this report and approved its publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

PREFACE

An impressive list of accomplishments can be posted in FY 1972 for the National Environmental Research Center (NERC) in Cincinnati. The most basic achievement was that NERC-Cincinnati began to function as the integrated environmental research organization envisioned by the Administrator in August 1971, when he formally designated it as the first of EPA's four national environmental research centers. The following report shows how this goal was reached, reveals the scope of our activities, and documents the progress made in environmental research here.

Research activities of each of the NERC laboratories in Cincinnati are summarized, and a number of contributions made by our staff members to international activities of the EPA are highlighted. Certain projects from the research activities have been chosen for special mention in the text. Also described is the first National Environmental Information Symposium, held in September 1972 and jointly planned and executed by the staff of NERC-Cincinnati and our Washington headquarters. As this report clearly indicates, FY 1972 has witnessed a significant step forward in the Cincinnati mission to develop pollution control technology in the fields of air, water, radiation, and solid waste.



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NERC-CINCINNATI AT A GLANCE

Introduction

The National Environmental Research Center (NERC) in Cincinnati, formed in August 1971 from research programs administered by EPA in the Cincinnati area, is one of four EPA research centers reporting to the Assistant Administrator, Office of Research and Development (OR&D). Water pollution control activities under Federal auspices in Cincinnati date back to 1913. Water supply research and radiological health programs were added in the intervening years, and during the 1960's, solid waste research was initiated here. Cincinnati-based air pollution control laboratories (except for an inhalation toxicological laboratory) were recently transferred to North Carolina.

NERC-Cincinnati presently consists of seven major laboratories conducting research in water, air, solid waste, and radiation. The principal research theme is the development of environmental protection technology. Secondary research themes also exist in the areas of health effects research and monitoring.

The total research and administrative staff of NERC-Cincinnati numbers about 500, including researchers at satellite laboratories in Edison, N.J., Narragansett, R.I., Dauphin Island, Ala., and Gig Harbor, Wash. The Advanced Waste Treatment Research Laboratory operates pilot plants in Blue Plains, Washington, D.C., Lebanon, Ohio, Pomona, Calif., and Crown, W.Va. The Cincinnati environmental research effort has produced a significant cadre of dedicated researchers, many of whom occupy key positions throughout the Office of Research and Development.

The various administrative and laboratory organizations of NERC-Cincinnati and a brief description of each operation are given below.

Office of the Director

The Director of the National Environmental Research Center in Cincinnati is responsible for the overall direction of the research programs assigned to the seven NERC laboratories. The major staff functions in the Office of the Director include program coordination, technical information, public affairs, civil rights, and urban affairs. A separate Office of Administration provides other services including the NERC library (which functions as EPA's central technical library), computer services, and personnel services.

NERC Laboratories

The Directors of the seven NERC laboratories in Cincinnati are responsible for the day-to-day implementation and administration of the research programs assigned to them. The laboratory directors plan their research programs under the overall direction

of ORD headquarters and the NERC Director, who approve all plans and the expenditure of resources consistent with these plans. Research is conducted directly by NERC investigators or through the use of extramural contracts and grants, with NERC researchers serving as project officers. The results of this research are published both in engineering and scientific journals and in an EPA technical report series.

The scope of the research programs at NERC-Cincinnati ranges from basic developmental or investigative studies to full-scale demonstration projects. The output of the research program is available to a wide range of users: to public or private agencies for design and construction of pollution control facilities, to EPA enforcement groups for technical back-up, to EPA programs concerned with the establishment of guidelines, and to private and university research laboratories for support of their own work.

The seven NERC laboratories in Cincinnati are as follows:

1. Advanced Waste Treatment Research Laboratory. The AWTRL program develops and demonstrates practicable means of treating municipal sewage and polluted mine water, handles sludge, and estimates the costs of treatment processes.

2. Edison Water Quality Research Laboratory. The EWQRL program develops and demonstrates practicable means of (a) treating or otherwise handling wastewaters from storm and combined sewer overflows, heavy industrial sources, watercraft and recreational sources, and (b) controlling spills of oil and hazardous materials.

3. Water Supply Research Laboratory. The WSRL program performs research necessary to establish drinking water standards so that drinking water will be safe and otherwise acceptable to consumers. The WSRL studies health effects and develops suitable water treatment technology and methodology.

4. Solid Waste Research Laboratory. The SWRL program develops and demonstrates technology and systems for the management of solid waste. Research areas include the generation, storage, collection, transport, processing for disposal or resource recovery, and ultimate disposal of solid waste.

5. Analytical Quality Control Laboratory. The AQCL program (a) develops physical, biological, and microbiological methods for the analysis of water, wastewater, and sediment; (b) evaluates method reliability, analyst performance, and quality control techniques; and (c) develops instrumentation for environmental monitoring.

6. Environmental Toxicology Research Laboratory. The ETRL program in biomedical research determines the toxicological effects of fuel and fuel additive emissions to provide health-related data for development of EPA emission control regulations. The data are also used for the development of air pollution criteria and standards.

7. Radiochemistry and Nuclear Engineering Research Laboratory. The RNERL program for monitoring quality assurance quantifies and qualitates radioactive discharges at nuclear power stations and associated facilities. RNERL also develops radiochemical analytical methods and guidelines for radiological monitoring systems.

The activities of each of these laboratories are discussed under "Laboratory Reviews."

Facilities

The Office of the Director and most of the wastewater treatment and drinking water research staffs are located in the Robert A. Taft Laboratory in Cincinnati. Several other buildings in and around the city house other NERC programs. In all, there are four major facilities in Cincinnati. By the end of 1975, a major new facility now under construction adjacent to the University of Cincinnatil will house many NERC-Cincinnati programs; the world-renowned "Taft Center" will remain a NERC facility, however.

Budget and Personnel

The budget and personnel of each NERC laboratory are presented in Tables 1 and 2, with some breakdown by activity to illustrate the level of effort being devoted to major categories of research.

LABORATORIES

ADVANCED WASTE TREATMENT RESEARCH LABORATORY

The advanced waste treatment program was initiated in Cincinnati in 1960 under the Federal Water Pollution Control Act. Until the establishment of EPA in December 1970, research here was conducted under auspices of the Public Health Service, and later the Federal Water Quality Administration.

The Advanced Waste Treatment Research Laboratory (AWTRL) develops and improves methods for wastewater treatment and reuse. Most of our studies are centered on municipal wastewater treatment; however, much of the methodology is also adaptable to treatment systems for industrial and agricultural wastewaters.

High-priority projects at AWTRL in 1972 (and continuing in 1973) are removal of oxygen-demanding materials from municipal wastewaters, removal of nutrients such as phosphorous, ammonia, and nitrate nitrogen, and improved techniques for removing and handling sludge from treatment plants.

In the area of disinfection, emphasis is on removal or destruction of viruses. Water reuse studies are concentrated on development of treatment systems capable of reducing the amounts of trace metals and pathogens in reusable waters.

Cost effectiveness studies are an integral part of all new technology developments at AWTRL. The economic feasibility of applying new treatment systems is rigorously investigated to assure that our processes, instrumentation, and control devices are economically adaptable to the waste treatment industry.

Contracts and Grants

Advanced waste treatment research at NERC-Cincinnati is conducted through both intramural work and grants and contracts to extramural groups.

Demonstration grants are made to support research that is well enough

TABLE 1. NERC BUDGET - FY 1972

	Intramural ($1000)	Extramural ($1000)	Total ($1000)
Office of the Director	395.4	---	395.4
Advanced Waste Treatment Research Laboratory			
Treatment Process Development	1920.6	1803.8	3724.4
Mining Sources of Pollution	548.6	1356.8	1905.4
Municipal Sewered Wastes	287.6	2121.4	2409.0
Methods Development	212.2	307.7	519.9
Non-Sewered Wastes	30.0	65.9	95.9
TOTAL	2999.0	5655.6	8654.6
Edison Water Quality Research Laboratory			
Oil & Hazardous Material Spills	686.2	4319.5	5005.7
Storm & Combined Sewers	90.0	3808.0	3898.0
Transportation Sources of Pollution	73.0	806.0	879.0
Heavy Industrial Sources of Pollution	70.5	114.0	184.5
TOTAL	919.7	9047.5	9967.2
Water Supply Research Laboratory			
Health Effects	1314.0	---	1314.0
Process Development	800.0	100.0	900.0
Technical Assistance	380.0	---	380.0
TOTAL	2494.0	100.0	2594.0
Solid Waste Research Laboratory			
Disposal Technology	341.0	1775.6	2116.6
Resource Recovery	402.3	3314.0	3716.3
Collection/Processing Technology	479.5	1346.5	1826.0
Hazardous Solid Wastes	---	---	---
Behavioral Research	---	---	---
TOTAL	1222.8	6436.1	7658.9
Analytical Quality Control Laboratory			
Methods Development	1041.0	415.1	1456.1
Methods Standardization	---	---	---
TOTAL	1041.0	415.1	1456.1
Environmental Toxicology Research Laboratory			
Biomedical Research	1010.0	---	1010.0
Radiochemistry & Nuclear Engineering Research Laboratory			
Radiochemical Measurements	140.6	---	140.6
TOTAL NERC-CINCINNATI	10,222.5	21,654.3	31,876.8

TABLE 2. NERC BUDGET - FY 1973
(6-30-73)

	Intramural ($1000)	Extramural ($1000)	Total ($1000)
Office of the Director	771.5	---	771.5
Advanced Waste Treatment Research Laboratory			
Treatment Process Development	1982.3	1849.1	3831.4
Mining Sources of Pollution	475.2	1754.3	2229.5
Municipal Sewered Wastes	293.6	814.2	1107.8
Methods Development	221.6	275.0	496.6
Non-Sewered Wastes	41.7	---	41.7
TOTAL	3014.4	4692.6	7707.0
Edison Water Quality Research Laboratory			
Oil and Hazardous Materials Spills	524.6	2780.9	3305.5
Storm and Combined Sewers	160.1	2407.0	2567.1
Transportation Sources of Pollution	83.9	417.8	501.7
Heavy Industrial Sources of Pollution	102.7	306.9	409.6
TOTAL	871.3	5912.6	6783.9
Water Supply Research Laboratory			
Health Effects	1315.8	139.0	1454.8
Process Development	634.6	89.0	723.6
Technical Assistance	392.8	---	392.8
TOTAL	2343.2	228.0	2571.2
Solid Waste Research Laboratory			
Disposal Technology	464.2	451.7	915.9
Resource Recovery	263.9	341.0	604.9
Collection Processing Technology	145.7	177.9	323.6
Hazardous Solid Wastes	93.9	224.5	318.4
Behavioral Research	134.6	---	134.6
TOTAL	1102.3	1195.1	2297.4
Analytical Quality Control Laboratory			
Methods Development	898.3	101.0	999.3
Methods Standardization	262.9	---	262.9
TOTAL	1161.2	101.0	1262.2
Environmental Toxicology Research Laboratory			
Biomedical Research	1116.5	112.0	1228.5
Radiochemistry and Nuclear Engineering Research Laboratory			
Radiochemical Measurements	136.4	---	136.4
TOTAL NERC-CINCINNATI	10,516.8	12,241.3	22,758.1

developed to warrant evaluation of processes and systems at full scale treatment plants.

Intramural work conducted at the Robert A. Taft Laboratory in Cincinnati includes pilot plant studies in biological and physical-chemical treatment. Additional intramural research is conducted in cooperation with municipalities in the pilot plants at Blue Plains near Washington, D.C.; Lebanon, Ohio; and Pomona, California.

FY 73 Budget

Table 3 presents the FY 1973 AWTRL budget for municipal wastewater treatment research.

1972 Research

Oxygen-Aeration Systems

Oxygen-aeration of wastewater is a biological treatment process of high reliability, which promises savings in aeration volume, power, and sludge production. Pilot-plant work in this process is continuing at the Blue Plains facility. Demonstration projects at Las Virgenes, California and New York City's Newtown Creek Plant is providing valuable design data.

In 1972, a contract was negotiated with the Martin-Marietta Company to demonstrate a modified oxygen-aeration system. Work also began at Lebanon, Ohio on an oxygen expanded-bed contacting system.

TABLE 3. ESTIMATED FY 1973 BUDGET BREAKDOWN FOR AWTRL

Category	Amount
Demonstration of advanced technology to achieve non-polluting municipal discharges	$1,380,000
Ultimate disposal of sludges	910,000
Removal of phosphorus and nitrogen	780,000
Instrumentation and process control	530,000
Removal and enumeration methods for virus	500,000
Upgrading of biological treatment methods and development of new methods	450,000
Renovation and reuse of wastewater	300,000
Development of physical-chemical treatment	300,000
Treatability of organic compounds	220,000
Destruction of pathogens	200,000
Treatment process and system optimization	100,000
Removal of inorganic materials including trace elements	50,000
Development of small treatment systems	40,000

Major Construction

Work on three major demonstration projects proceeded apace in 1972. A tertiary treatment plant at Ely, Minnesota was completed and operation of the 1.5 mgd plant was begun. The Ely project will help restore water quality of Shagawa Lake by limiting phosphorus in discharges to the lake to 0.05-0.10 mg/l P by use of tertiary lime clarification followed by filtration.

Construction of the advanced waste treatment plant at Piscataway, Maryland was also completed in 1972. The second largest AWT plant in the country, the Piscataway installation is now operating on a flow scheme of two-stage lime clarification gravity-thickening, dewatering, recalcination, gravity dual-media filtration, neutralization and carbon absorption and regeneration system.

At Muskegon, Michigan, work is continuing on construction of the wastewater management system plant which is designed to demonstrate a wastewater management system utilizing spray irrigation to handle combined municipal and industrial flows totaling 42 mgd with an ultimate peak of 90 mgd.

Nutrient Removal

The most thoroughly evaluated processes for nutrient removal are the mineral-addition processes for phosphorus precipitation and the three-stage biological system for nitrogen removal. During 1972, at the Blue Plains Pilot Plant, a full year's demonstration of a combination of these processes to provide combined carbon, nitrogen and phosphorus removal was completed. Operation of this flow scheme provided design data for expanding and modifying the District of Columbia Treatment Plant. Mineral addition for removing phosphorus was studied in conventional plants. Full-scale studies of alum and iron additions at Pomona and Lebanon confirmed the utility of mineral addition to both the primary clarifier and the aerator of an activated sludge plant.

Another promising process for nitrogen removal, breakpoint chlorination, was studied at Owosso, Michigan and Washington, D.C. Almost complete removal of ammonia nitrogen was achieved and residual free chlorine and chloramines were removed by short contact with activated carbon. The process results in increased chloride content; however, where mineral content of the water is not an important consideration, the increased chloride content would be negligible.

At Pomona, a full year's evaluation was completed of a two-stage carbon adsorption system in which a comparison was made of the operating characteristics of two commercially available granular activated carbons. Currently under evaluation at Pomona is a carbon system being fed with chemically treated raw sewage.

Reverse osmosis was studied at Lebanon and Pomona to develop data for defining an optimum pretreatment method. The work at Lebanon showed that "fiber configurations" are not acceptable for municipal wastewater applications.

Physical-Chemical Treatment

Data obtained through 1972 permit increased confidence that physical-chemical treatment is a viable alter-

nate to biological treatment. There are a number of possible systems of both types. While there exist several criteria for making a choice, the most important factor is the amount of certain industrial wastes in the wastewater. Biological systems are more susceptible to upset by a variety of industrial wastes. During the past year a completely automatically controlled physical-chemical system was demonstrated at Washington, D.C. The treatment system demonstrated included two-stage lime clarification, filtration, carbon adsorption, and breakpoint chlorination, giving high level carbon, nitrogen, and phosphorus removal. New P-C and biological systems are capable of producing effluent organic pollutant levels almost an order of magnitude lower than conventional primary-plus-secondary treatment. Both systems also provide nitrogen and phosphorus removal if mineral addition to the aerator is included in the biological system.

Other Research

Numerous other aspects of wastewater treatment were explored at AWTRL in 1972. Powdered carbon treatment was investigated in the laboratory and in pilot plants in Cincinnati and Salt Lake City. Combined with chemical coagulation and granular media filtration, one-time use of carbon is economically attractive for the smaller plant where installation and operation of a carbon regeneration furnace is difficult to justify.

Methods of upgrading trickling filters were investigated. One involves alum addition to the final clarifier with recirculation of settled sludge to the primary clarifier. This technique was evaluated at Richardson, Texas and similar work is continuing at Chapel Hill, North Carolina. Excellent results were obtained at both facilities, with significant improvement in organic carbon, suspended solids and coliform removals, as well as efficient phosphorus precipitation.

Pilot ozone treatment carried out at Washington, D.C. showed that this method is excellent for organic oxidation. In addition, the method provides disinfection without producing the secondary pollution which may result from use of chlorine. Improved reactor design is expected to reduce costs and to make ozone treatment more economically attractive.

The ability of physical chemical treatment to remove 12 different heavy metals was evaluated in pilot plants at Cincinnati. The processes of chemical precipitation by lime or ferric sulfate, granular media filtration and activated carbon adsorption were shown capable of removing over 98% of most of the metals studied. The metals were concentrated in the chemical-organic sludge, indicating a need for concern for disposal of sludges with increased metal content.

Research was begun on the removal of the thousands of synthetic organic chemicals which are being discharged to municipal sewers. Many of these compounds are not degradable and cannot be substantially removed by conventional biological processes. Some of the compounds are toxic to man or lower animals. Virtually nothing is known about the fate of specific organic compounds in physical-chemical processes. A recently initiated AWTRL study seeks to determine the capabil-

ities of physical-chemical processes to remove organic compounds selected on the basis of their hazards to man or to water quality. Thus far, P-C processes have shown excellent capability for removal of pentachlorophenol, styrene and diethylene glycol.

Virus Removal

Large quantities of viruses of human origin are present in sewage, sewage effluents, and in rivers and streams. Since very small amounts of viruses can produce infection in man, as complete removal as possible is desirable.

The Virology Program of AWTRL is devoted to the development of methods for removing and destroying viruses in waste, renovated, and other waters, development of methods for detecting small amounts of viruses in large volumes of water, assessment of the hazards of various groups of viruses present in waste and natural waters, and support of enforcement efforts.

Viral removal effectiveness of the three-stage activated sludge system is under study at the Washington, D.C., pilot plant. This type of treatment is to be adopted by the District of Columbia. Considerable daily fluctuations have been found in both viral and bacterial populations with peak hours appearing in the late afternoon and extending into the evening hours. Seeding was done with a bacterial virus coliphage f_2 similar to poliovirus in structure and size but harmless to humans, at levels about 500 times that of the natural coliphage background. With only one exception, the data revealed 90% or greater reduction of the virus in the three sludge process.

The relative effectiveness of chlorine and iodine, their compounds, and ozone are being evaluated as disinfectants for effluents, renovated wastewater, and other waters under a cooperative project between the University of Cincinnati, Hebrew University in Israel, and AWTRL. Hypochlorous acid (a form of chlorine) and ozone were found to be rapid virucides and bactericides in clean water. Iodine may be more effective than chlorine for certain effluents, however, because it does not suffer a reduction in effectiveness in the presence of ammonia as chlorine does. Final analysis of the data from the completed study will permit determination of the most effective disinfectant for any use situation.

A major program has been dedicated to acquiring the capability for detecting and identifying small amounts of viruses in large volumes of water. Methodology developed under a grant to Baylor University now permits sampling of 100-gallon quantities or more. At AWTRL a system has been developed which considerably reduces the cost of testing filter systems for virus removal and recovery capability. An asbestos-wood pulp disc, effective with this system, has been singled out for further study.

Another method for reducing costs in virus work has been developed. Viruses are grown in living cells, and those prepared freshly each week from living animals are among the largest cost items of the virus laboratory. A cell line (BGM) has been found that is inexpensive to propagate and is more sensitive to viruses in field evaluations than expensive primary rhesus monkey cultures. A considerable

cost saving has resulted from use of this cell line.

We have also found that it may be feasible to process large volumes of water at sampling sites and then return only the membranes containing the adsorbed viruses to the laboratory for virus recovery. After adsorption on the membrane and refrigeration at 4 C, two viruses, poliovirus 1 and echovirus 7, could be stored for 3 days before there was a substantial loss in their recovery. This new method may also result in a large cost saving.

The Virology Program has contributed significantly to enforcement actions. Early this year, in support of a Federal court action in New Jersey against discharging sludge into coastal waters, viruses were recovered from both sludge and seawater samples. Testimony given in support of the data was critical in winning a landmark enforcement decision against ocean disposal under the Refuse Act of 1899.

More recently, samples from the Wabash River in the vicinity of Vincennes, Indiana, along with raw and treated sewage from the city's plant, were surveyed for viruses in support of an enforcement action by the EPA Region V District Office at Evansville, Indiana. Viruses have been recovered from the Vincennes treated wastewater effluent and from several of the collected river water samples.

Ultimate Disposal

Ultimate disposal is concerned with the handling, processing, transporting, and disposal of sludges and brines removed from wastewater treatment processes. The program emphasis has been on sludge disposal. Brine disposal is of less interest presently because large scale implementation of brine-producing demineralization methods has not yet been necessary.

Although sludge is often mistakenly considered to be solid waste, it actually contains far more water than solids. Removal of this water, or devising a new way to bypass the water removal step, is one of the most important problems in sludge disposal. For final disposal, the primary methods are incineration, landfill including "permanent" lagoons, and land spreading. For land spreading, pretreatment methods have been investigated to make the sludge innocuous. Also, efforts have been devoted to by-product recovery from the sludge. Increased mineral content of sludge from physical-chemical treatment has also been of major concern.

An improved method for dewatering appears possible from modification of a vacuum filter in Milwaukee to operate in the top-feed mode. A grant application has been received to further demonstrate this idea. Westinghouse is studying the dewatering of sludge using capillary suction (Figure 1). This method removes water by an action similar to a sponge but uses an endless belt. A pilot machine large enough to handle all of the waste activated sludge from a 2 mgd plant is routinely dewatering a 1% sludge to 18% solids with 98% capture. Conventional pressure filters using ash as a filter aid are being demonstrated for dewatering at Cedar Rapids, Iowa. Both fly ash from coal and incinerator ash may be used. The major advantage of pressure filtration is that the final cake is dry enough to incinerate without added fuel.

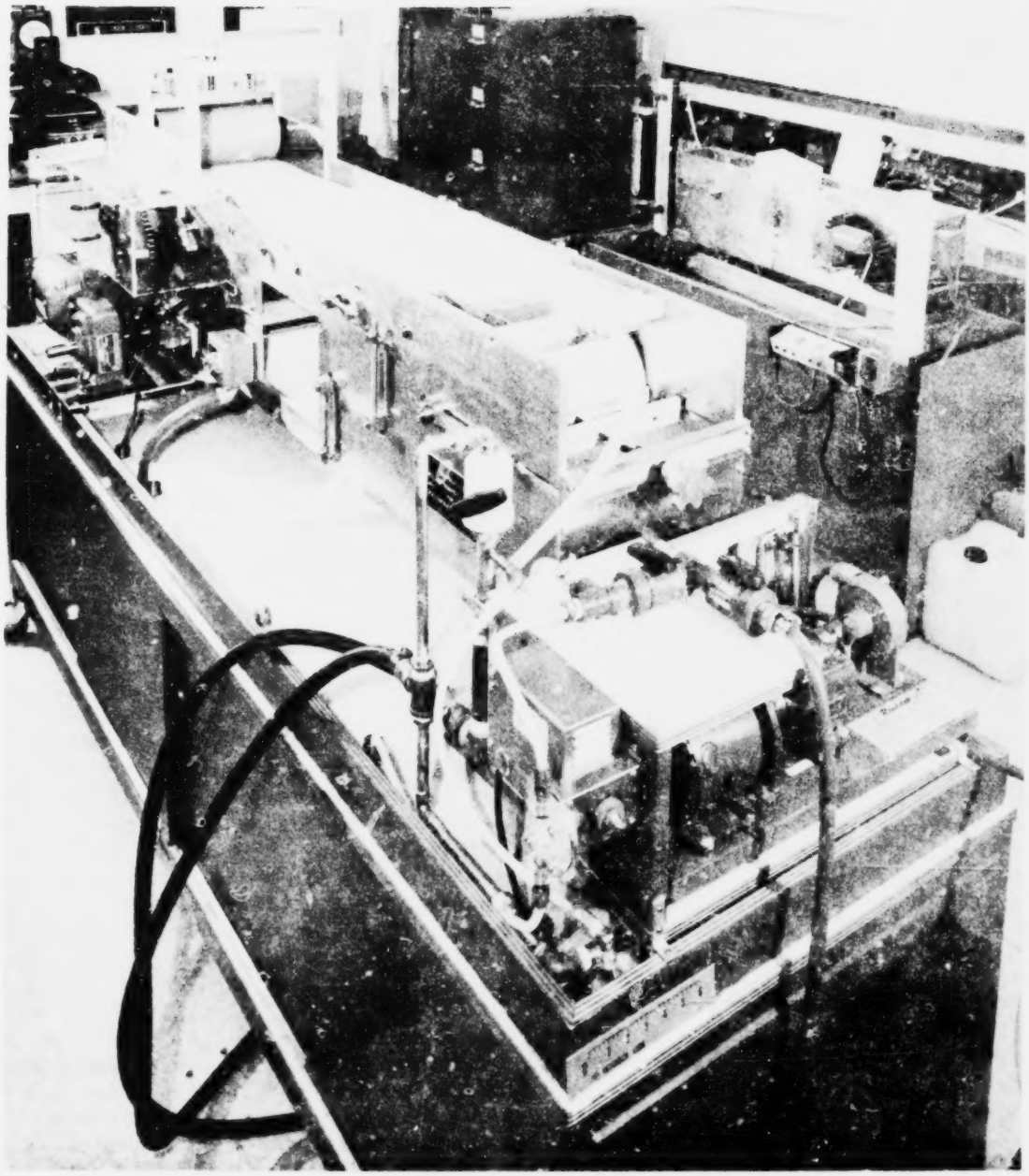

Figure 1. Dewatering of sludge by capillary suction

Aerobic stabilization circumvents many of the problems of conventional anaerobic digestion and appears to be particularly useful with land disposal of sludge. This method has been shown to be attractive in laboratory and pilot plant studies at Cincinnati and at a grant project in Hollywood, Florida. Process parameters will be further defined with a demonstration project being initiated at Denver. Stabilization using lime has also been studied and a contract has been let with Battelle-Northwest to evaluate this process.

Although incineration and deposition in landfills are common methods for disposal of dewatered sludge, they are costly because 85% to 95% of the water must first be removed. Incineration can also cause air pollution unless costly afterburners, scrubbers, and automatic controls are installed. Direct application of wet sludge to the land can be a lower cost method and can also improve the soil. Chicago has pioneered in large-scale land disposal of wet sludge and is now shipping sludge 200 miles to rehabilitate strip mined areas. Technical factors limiting sludge application appear to be nitrogen and heavy metals; however, a lack of public acceptance of land spreading in new areas has stopped some projects that had high technical merit. Land disposal of total sewage using the soil as a "living filter" can be used in some areas provided that the hydraulic acceptance of the soil is adequate. Since sludge represents less than 1% of sewage flow, disposal of sludge to the land is less likely to be limited by poor hydraulic permeability of the soil than is direct application of sewage. Several coastal communities have submitted proposals to study land disposal of sludge as an alternative to ocean dumping. Ocean County, New Jersey, has already received a grant.

By-product recovery and recycling are more desirable than disposal by incineration and land spreading. The South Tahoe Public Utility District has demonstrated the practice of recovering lime, but other recent attempts at by-product recovery have not been as successful. A contract with Monsanto showed little economic incentive for recovery of phosphates. Foster D. Snell, Inc., has been studying the recovery of amino acids as the basis of an animal feed supplement and has shown that the product does not produce abnormal growth or birth defects in test animals. An economical process for recovering the amino acids is still under study.

Treatment Costs and Operation

Cost and design information from projects and other sources was compiled to provide a basis for determining the cost effectiveness of treatment systems. A significant event during the past year was the publication of "Estimating Cost and Manpower Requirements for Conventional Wastewater Treatment Facilities" EPA Water Pollution Control Research Series, Report No. 17090DAN10/71, the final report on a study conducted by Black and Veatch Consulting Engineers. Regressions have been made of data in the Black and Veatch report and a computer program was developed for sizing and costing conventional wastewater treatment processes. The program was also modified to include the cost of chemical addition for phosphorus removal, including the cost of extra sludge handling.

Other projects during the year consisted of efforts in the areas of computer design programs, costs, and instrumentation and automation. Computer programs for designing pressure vessels and concrete tanks were completed. Cost studies were done on physical-chemical and other advanced treatment methods, alum and methanol addition, wastewater renovation, and automation. A report was completed on electrical power consumption for municipal wastewater treatment.

More emphasis was placed on instrumentation and automation of plants with a project being initiated for compilation of the present state-of-the-art related to wastewater treatment. Intramural evaluation of ammonia probes for application to process control is also underway. If satisfactory performance of a probe can be obtained it can be of significant value to nitrogen removal treatment processes.

Mine Drainage Pollution Control Activities

The Mine Drainage Pollution Control Activities program performs research, development, and demonstrations on the control of environmental problems from mining operations on a nationwide scale. The program is divided into five areas of concern: surface mining, underground mining, new mining methods, treatment of mine drainage, and demonstrations of economical and practical control methods.

During the past year major strides have been made in developing methods for analyzing overburden from surface mines as a technique for preplanning the mining operation. Through a grant to West Virginia University, methods of analyzing core-boring and rock chips to predict the potential of the various strata to create acid mine drainage problems, or a difficult revegetation problem, are being evaluated. With this information, the mine operator can selectively remove and place the material to minimize the environmental damages during and following mining and to facilitate the stabilization of the area through revegetation.

Further progress was made on the development of the permeable limestone mine seal. Flooding of underground mines by placement of a "bulkhead" seal in the mine openings has been found to be an effective means of controlling acid mine drainage. The major drawback of this method is the high cost of the seal. A cheaper seal was developed and patented through an EPA grant. This seal is constructed by pneumatically placing limestone in the mine opening and grouting the top for a tight fit. As the acid mine drainage flows through the limestone, it is neutralized and a ferric hydroxide-calcium sulfate precipitate forms that fills and plugs the opening in the limestone barrier. Thus, the barrier treats the water until it is self-sealed. Current work deals with the optimization of the seal construction, e.g., the sizing of limestone in the seal.

If an underground mine can be operated in an inert atmosphere, then acid mine drainage, explosion, and health problems can be eliminated. In order to mine in an inert atmosphere, the miners themselves must have a self-contained atmosphere. An EPA grant to Island Creek Coal Company has been used to develop and

test a Miners' Life Support System (MLSS). MLSS is based upon the "space suits" developed by NASA. The MLSS is being tested under actual mining systems and shows great promise of success.

During active mining and in those situations where control techniques are not available, mine drainage must be treated. Currently the mine drainage is neutralized with lime, aerated and the resulting sludge removed by settling and disposed of by lagooning. The drawbacks of the process are the high cost of lime and the high volume of low solids sludge produced. Research by EPA has shown that a limestone-lime process can reduce the reagent cost by 25%, decrease the sludge volume by one-half and increase the sludge solids content by four times. The limestone-lime process consists of neutralizing the mine drainage with ground limestone to a pH of 4.5, to take advantage of the reactive pH zone of limestone and the low reagent cost, then polishing the water with lime to the desired pH (Figure 2).

Reverse osmosis has been shown to be an effective method of treating acid mine drainage to produce a high quality of water for domestic and industrial use. However, where mine drainage high in ferrous iron was treated, a severe fouling of the membrane occured due to iron. EPA and the Commonwealth of Pennsylvania studied this problem and found that the fouling of the membrane was due to bacterial oxidation of the ferrous iron on the membrane surface and that it could be controlled by lowering the pH of the raw water to 2.5 or pretreating the water with ultraviolet light.

Section 14 of the original Federal Water Pollution Control Act established a program to demonstrate economic feasibility and practical techniques for the abatement of mine drainage. During 1972 three new projects were initiated, bringing the total number of projects to eight. The state of Maryland was awarded a grant to demonstrate the elimination of an underground mine drainage problem by removing the entire overburden to convert the underground mine to a strip mine, making it possible to use conventional strip mining and land reclamation techniques. This process is termed "daylighting." The use and effectiveness of control structures to prevent stream siltation from strip mining activities will be demonstrated in Kentucky. A West Virginia project will deal with the insertion of an impermeable trench in a surface mine backfill to seal off the leakage from an underground mine.

Section 107 of the Federal Water Pollution Control Act Amendments of 1972 has expanded the scope of Section 14 to emphasize the utilization of waste materials to reduce pollution from minine activities. Discussions have been held with a number of states who are developing proposed demonstrations to utilize waste materials as proposed by the Law.

Technology Transfer

In addition to providing improved treatment methods through research and development projects, laboratory staff contributed to EPA Technology Transfer seminars and design manuals. During 1971, process design manuals were issued in four areas: Upgrading Existing Wastewater Treatment Plants, Suspended Solids Removal, Phosphorus

Removal, and Carbon Adsorption. These manuals are now being updated to incorporate newly developed technology. A new manual on Sulfide and Odor Control is also being prepared.

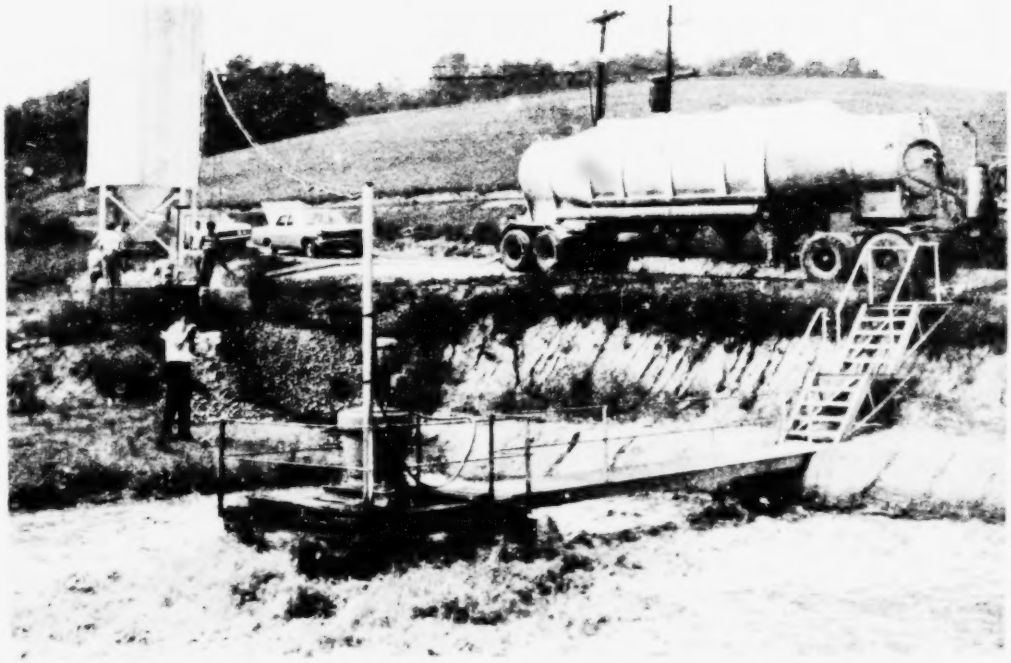

Figure 2. Lime neutralization plant treating mine drainage near Morgantown, West Virginia

ANALYTICAL QUALITY CONTROL LABORATORY

The Analytical Quality Control Laboratory research programs are devoted principally to the development of analytical methods and monitoring technology, to evaluation of the reliability of methods and of analyst performance, and to the establishment of quality control techniques.

Research projects have included development and improvement of analytical methods for inorganic ions in water and wastes, heavy metals in industrial wastes, pesticides in surface waters, and characterization of petroleum products from oil spills. Biological investigations covered macroinvertebrate sampling and identification, the development of improved biomass measurements, and the preparation of an EPA manual for field and laboratory biological methods. Microbiological methods were examined and improved, including procedures for total coliform organisms by membrane filter, fecal coliform, and fecal streptococci techniques. A procedure for delayed incubation of fecal coliform membranes was investigated.

A full series of reference samples for major constituents in water was prepared and distributed to cooperating laboratories. More than 2000 sets of samples were distributed in FY 72. These samples provided a valuable service in laboratory quality control and evaluation of performance.

Method studies for the evaluation of approved EPA analytical procedures yielded data from more than 100 laboratories on methods for mercury, nutrients, oxygen demand and organic carbon, and mineral constituents. Studies on procedures for heavy metals and chlorophyl were initiated. Reports were issued on manual methods for nutrients and procedures for biochemical and chemical oxygen demand and total organic carbon.

Improvements in automatic monitoring instrumentation included a better dissolved oxygen system, the design of a flow cell to provide self-cleaning of sensors, and selection of new pumping equipment to overcome siltation and corrosion. Data acquisition by computer was initiated and new interface and output devices were developed.

The Analytical Quality Control Newsletter, begun in FY 70, was expanded to cover broader technical areas and the distribution was increased to 5000 readers.

Analytical methods for the identification of clandestine oil spill materials were developed, based on the use of infrared ratios. The technique was originated at the Laboratory and has been widely accepted in the petroleum industry. Extension to other instrumental measurements, in conjunction with IR, were initiated in FY 72.

Technical assistance was provided to other EPA programs through advice on analytical methods, laboratory examination of industrial waste samples, identification of petroleum products with preparation of enforcement affidavit, training course development in quality control techniques, and consultation with research project officers on grant and contract laboratory performance.

Among the major accomplishments the Laboratory were:

- distribution of more than 20,000 copies of "Methods for Chemical Analysis of Water and Wastes"
- preparation and distribution of "Methods for Organic Pesticides in Water and Wastewater"
- preparation of a "Handbook for Analytical Quality Control in Water and Wastewater Laboratories"
- laboratory investigations and final recommendation of methods for total and methyl mercury in water, sediments, and fish
- development of gas chromatograph/mass spectrometer techniques for identification of organic pollutants in industrial wastes
- operation of a ground-to-satellite transmission system for water quality monitoring, involving an EPA in situ data acquisition system and the NIMBUS satellite.

EDISON WATER QUALITY RESEARCH LABORATORY

The Edison Water Quality Research Laboratory (EWQRL) develops new process technology in a number of complementary areas of water pollution abatement. The work may be grouped into four main areas: oil and hazardous material spill control, industrial effluent control, storm and combined sewer overflow management, and waste management from recreational and transporation sources.

In the area of spill control, special emphasis is placed on control of oil spills. The industrial waste control program deals primarily with waste from the electroplating and non-ferrous metal industries. The storm and combined sewer overflow program develops and demonstrates management concepts via full-scale municipal tests designed to abate pollution caused by wet weather flows. Waste management for small boats has been the main thrust of the transportation program.

Oil Spill Research Program

The prime responsibility of this program is to develop the technology and systems necessary to prevent, contain, monitor, control, identify, and clean up spills of petroleum and petroleum products. The following projects represent major accomplishments of this program.

Melloy Laboratories demonstrated that the froth flotation technique for ore separation could also be used to remove oil from contaminated beach sand. A prototype unit was built, tested, and delivered to EWQRL. This unit, consisting of four flotation cells, is mounted on a 40-foot flatbed trailer. It has a through-put capacity of 30 tons of oiled sand per hour. The effluent sand is clean enough for replacement on the beach.

The JBF Scientific Corporation demonstrated the Dynamic Inclined Plane

(DIP) Oil Harvester. This unit, several different sized models of which are currently available, has a skimming efficiency of better than 90% in 2-foot harbor waves at 2 knots relative velocity. The principle operation has been adopted for use in units sold to the State of Massachusetts and the Navy Department.

To provide the much-needed transition between laboratory work and actual spill conditions, a large wave tank is being constructed in which equipment and procedures for handling spills of oil and hazardous materials can be developed, tested, refined, and evaluated without harming the environment. The 667 x 65 x 11 foot tank will be completed in the fall of 1973 and is located at Earle, New Jersey.

An intramural effort has produced an oil measurement technique good down to 100 ppm of oil in water. By modifying the sample preparation step, the measurement can be extended to the 50 ppm level in both water and sediment samples.

Hazardous Materials Spills Program

The Hazardous Materials Spills Research Branch of EWQRL develops technology and systems for preventing, detecting, identifying, containing, monitoring, controlling, and cleaning up in the water environment spills of hazardous substances that dissolve in or react with water or that sink, float, or volatilize. Some examples of hazardous materials are: phenol, alcohol, nitric acid, chlorosulfonic acid, acetone cyanohydrin, toluene diisocyanate, organo-phosphate pesticides (Diazinon, parathion), chlordane, perchloroethylene, creosote, carbon disulfide, styrene, iso-octane, formaldehyde, and chlorine.

During 1972, significant progress was made in the areas of hazardous spill containment on land and in water. Spill treatment and detection devices were developed, and hazardous material information systems designed.

The feasibility of plugging leaking containers in the field using "foam plugs" was demonstrated. A system for dispensing "foamed-in-place" dikes was developed and tested. These dikes can be used on land to prevent spilled materials from reaching nearby watercourses or storm drains.

Several methods to prevent spilled materials from percolating into ground water were developed and tested, including the use of chemical additives to absorb, gel, or co-polymerize the material.

A sealed boom (water curtain) was developed and tested. This water curtain incorporates a flotation collar that supports the top of the barrier and a steam-bed conforming, water-filled cuff that seals the barrier to the bottom of the watercourse. The system provides EPA with the capability to isolate a spill in a section of a watercourse by surrounding it with the boom.

Several systems for treating spill-contaminated water were developed and evaluated: a truck-mounted dynactor-magnetic separator system (5 gpm), a "tea-bag" concept for in-stream treatment using mass transfer media, and a system for in-stream treatment using flotable mass transfer media.

The dynactor-magnetic separator system utilizes a thin film aerator device coupled with a special, high filtration-rate separator to treat water with activated carbon, ion-exchange resins, precipitating agents, neutralizing agents, and/or ozone. Simple aeration is also possible.

In the "tea-bag" method for removing dissolved spilled materials from streams, activated carbon is placed into sausage-like fabric sacks that are constructed to have sufficient head-end buoyancy to allow them to float vertically in the watercourse. The bags drift slightly out of phase with the gross movement of the slug of pollutant in the stream. Thus, when the bags are introduced at the leading edge of the slug, they gradually sweep to the trailing edge and adsorb pollutant during their transit.

The system for using flotable mass-transfer media uses weighted containers which are filled with activated carbon or ion-exchange resins. After the containers sink to the bottom of the watercourse, the resin or carbon is released slowly and then floats to the surface, adsorbing the dissolved pollutant during transit of the water column. The spent sorbent (carbon or resin) is later harvested and removed from the surface by conventional skimming techniques.

Several devices for detecting spills of hazardous materials were developed. These include a detector for dissolved organo-phosphate and carbamate pesticides (pesticide-inhibited cholinesterase activity is measured electronically), a modulated cyclic colorimeter for heavy metals, and a sensitive vapor-sensing device for volatile organics. A detection kit was also developed to aid field personnel in locating and identifying spills.

To aid the spill-response personnel of EPA and other Federal agencies, a handbook of procedures to be followed for the disposal of small lots of unused pesticides was prepared. A handbook of techniques for assessing the damage caused by spills was also completed. In addition, the first Conference on the Control and Prevention of Hazardous Material Spills was held under EPA sponsorship during March 1972 in Houston, Texas.

A contingency plan for handling spills of hazardous materials in municipalities is being developed. A major part of the work is directed toward keeping the spill from entering the sewer system. For those spills that do enter a sewage treatment plant, operational procedures for maintaining the efficiency of secondary treatment are being tested.

The hazards to aquatic food chains and to water quality are being assessed in a project studying spillage and release of thallium and other heavy metals (copper, lead, zinc) from ore mining, milling, smelting, and electroreduction and chemical processing.

A readily transportable field-use pump and 7,000 gallon collection bag system is being fabricated to collect and temporarily store sumped or diked spills of hazardous materials.

A large "captive" site (the NASA Mississippi Test Facility, Hancock County, Mississippi) is being evaluated

as a facility for large-scale demonstrations of equipment for the prevention, control, containment, and disposal of spills of hazardous materials. The area has a well-characterized ecology, climate, geography, and hydrology. The nature of the terrain and the existence of an extensive canal system make the site potentially attractive for evaluating methods for preventing hazardous substances spilled on land from entering watercourses or the ground water table.

Industrial Waste Technology Program

The Industrial Waste Technology Branch is responsible for the development and demonstration of new and improved technology for the prevention, control, treatment, recovery, and reuse of wastes in the metal finishing, non-ferrous metals, and heavy chemicals industries.

The state-of-the-art review of metal finishing waste treatment was completed and published. The review examines the nature of metal finishing wastes, the impact of these wastes on sewers, sewage treatment plants and water bodies, current restrictions on disposal, and metal finishing waste treatment technology. A carbon adsorption system for treating cyanide and chromate metal finishing wastes was developed. It was demonstrated on a pilot plant scale and has potential application for the small metal plating companies. The effectiveness and economic feasibility of integrated chemical rinse treatment for a small metal finishing operation was also demonstrated.

A significant and troublesome problem in the metal finishing industry is the large amount of sludge produced by chemical waste treatment practice. A project has been completed which provides information on the nature of the sludges produced, the effects of weathering on these sludges disposed of on land sites, and the potential economics of the processes.

An evaluation of the water pollution control practices in the primary non-ferrous metal industries was completed. This study identifies the nature and extent of the pollution problems, the sources, characteristics and significance of the wastes, and the current water use and waste treatment/recovery practices of the industry.

A pollution abatement program for the copper industry was demonstrated at the Volco Brass and Wire Company in Kenilworth, New Jersey. This project involves process changes, recovery, treatment, and reuse of copper and brass mill wastes. The process changes eliminated chromate, ammonia and fluoride ions, and permitted reuse of the pickling baths. An electrolytic system recovers copper from the baths and an integrated rinse treatment system permits most of the water to be reused. The sludge produced contains sufficient copper to be salable. Costs for the new pickling, waste treatment, and recovery processes are $194 per day compared to an estimated cost of $540 per day for the former pickling treatment process.

Storm and Combined Sewer Technology Program

This program develops and demonstrates technology for controlling urban storm-generated runoff pollution. The major sources of this pollution are

divided into three categories: combined sewer overflows, storm sewer discharges, and non-sewered urban runoff. During 1972, the following major studies were made to advance storm and combined sewer pollution control.

Because of the intermittent and variable nature of storm flow, emphasis was given to the physical-chemical approach as a basis for independent satellite wet-weather flow treatment plants. Successful pilot scale developments and demonstrations included: (1) microstraining and fine mesh screening; (2) dual media, deep bed, high-rate filtration; (3) a swirl chamber for simultaneous flow regulation and solids separation; (4) combination screening-coagulation-dissolved air flotation; and (5) a system for injecting powdered carbon and coagulants into a pipeline, separation by tube-settling, polishing by multi-media filtration, and regeneration of chemical additives by fluidized-bed incineration.

Biological treatment systems were developed as auxiliary facilities for treating excess wet-weather flows at a conventional plant. Two such full-scale biological processes, one a plastic media high-rate trickling filter and the other employing contact stabilization, were demonstrated.

To provide feasible disinfection for the high and intermittent storm flows encountered, high-rate disinfection processes utilizing a corrugated baffle contact chamber to obtain good mixing and chlorine dioxide, a rapid oxidant, were evaluated. An electrochemical hypochlorite generator for on-site use has also been developed. Significant decreases in coliform counts have been obtained from an 11,000 cfs storm water pumpage disinfection system in New Orleans.

Combined sewer overflow storage systems are of crucial program importance because gross variations in flow must be equalized as much as possible prior to treatment. Four large full-scale holding tank systems have been demonstrated and satisfactory results obtained from a project in Seattle which relies on remote monitoring and computer assisted control to obtain in-sewer storage of storm flow. The program has developed and demonstrated the nationwide application of a storm-water management model for evaluating and planning a control system. Further work will develop a model decision-making capability for detailed design and operation purposes.

An instantaneous in situ suspended solids meter was also evaluated and shows promise for use as a prime sensing tool for automation and datamation.

Small-scale demonstrations have also been made for porous pavement to attentuate storm runoff, and a pump-storage-grinder unit and pressure sewer system.

A program overview report entitled "Management and Control of Combined Sewer Overflows," to transfer basic program technology has received international recognition in the municipal pollution abatement field.

Transportation and Recreational Waste Technology Program

The transportation wastes program is charged with the development of technology for the economic treatment of wastewater (including bilge and ballast discharges) from watercraft, technology to handle galley wastes and litter from boats, and to minimize engine emissions.

Seven systems for management of wastes on commercial and recreational watercraft are under study. The methods being studied include: filtration, screening, centrifugation, adsorption, incineration, and disinfection.

A recirculating waste management system for use on a large 50-man vessel was demonstrated. The demonstration of this waste treatment system in both the discharge and recycle operating modes has shown that the system can provide a high level of secondary treatment. Effluents contained both biochemical oxygen demand and suspended solids generally below 50 mg/l. Several macerator-chlorinators and a Microphor biological marine sanitation device were evaluated in the marine sanitation devices test facility.

Research in the watercraft area also included the development of inexpensive, compact, and automatic instrumentation which is capable of monitoring effluent from vessel waste treatment systems. These instruments will also have wide application shoreside at recreational and other remote areas.

Research is also underway to investigate the extent of pollution from outboard engine exhaust and its impact on the aquatic environment. Two current studies will provide the chemical, physical, and biological data needed to properly assess the outboard engine exhaust problem.

The treatment of recreational wastes is a major problem primarily because of the short-duration and high-load factor, and the need to provide a high level of treatment to protect the water quality of the recreational areas. With limited resources the program was able to support the design and fabrication of a recirculating catalytic oxidation waste treatment system for the Grand Targhee Ski Resort in Idaho, and the installation and operation of a non-aqueous recirculating waste treatment system at Mount Rushmore, South Dakota. Site preparation and the spreading of urea formaldehyde foam for a flora filter wastewater treatment demonstration at Delaware and Dillon Reservoir State Parks in Ohio was also completed.

ENVIRONMENTAL TOXICOLOGY RESEARCH LABORATORY

The Environmental Toxicology Research Laboratory evaluates potential toxic effects of fuels and fuel additive emissions from mobile and stationary sources in order to provide data in support of establishing environmental pollution standards. The Laboratory conducts definitive toxicologic investigations of individual potential pollutants found in various environmental media in order to provide information on the impact of pollution on man's health and well-being. The research program includes development and evaluation of protocols for definitive testing of toxic materials. This health effects research must necessarily be conducted primarily in non-human biological systems.

Since the probability of reproducing human response in animals increases

with the number and judicious selection of animal species, the research program utilizes several mammalian species, e.g., mice, rats, guinea pigs, rabbits, dogs, Syrian hamsters, non-human primates, and cats. The animal experimentation approach permits strict control of a large range of concentrations and durations of exposure, and allows detailed observations in tissues and organs to be made.

Research on the potentially toxic effects of mobile source emissions is complicated by the rapidly changing scope of fuels and fuel additives marketing, and development of new emission systems and control devices, e.g., catalytic converters. The ETRL uses a multi-disciplinary research approach in two major areas of environmental pollution:

1. Inhalation and ingestion studies of single pollutants with particular emphasis on hazardous substances (trace metals); and,

2. Inhalation exposure of fuel and fuel additive emissions from mobile sources, representing a complicated but realistic mixture of pollutants in the environment.

Single Pollutant Studies

Manganese

The organometallic compound 2-Methylcyclopentadienyl Manganese Tricarbonyl (MMT) is of current interest because of its possible use as an anti-knock agent in unleaded gasoline. The compound is presently marketed as a combustion improver for fuel oils and as a smoke depressant for diesel engines and stationary jet fuel power sources.

Ingestion of both Mn tricarbonyl and ^{54}Mn tricarbonyl produced uptake, concentration, and bioeffects in the liver and kidneys of rats. Rats exposed to Mn tricarbonyl vapor indicated early changes in the liver and the corneas. Single-dose embryotoxicity studies are in process on pregnant female rats given ^{54}Mn tricarbonyl to determine abnormalities and histological changes in the fetuses and to determine the ^{54}Mn radioactivity per fetus. Dilutions of less than 10^{-7} gm (as Mn in MMT) were lethal to both primary and passed cells in a tissue culture system utilizing primary lung cell cultures derived from che Chinese hamster. Cytogenetic toxicity decreased with higher dilutions and none was observed above 10^{-9}. Performance of monkeys, trained on a fixed interval schedule of reinforcement, was observed after acute administration of manganese dioxide. Although the study is not complete, raw data indicates that there was a suppression of response rates. Preliminary experiments have indicated that the intravenous administration of low levels of Mn elicits a reproducible change in the rat visual evoked potential.

Cadmium

The kinetic and metabolic fate of different compounds of cadmium were investigated to provide information about this potential pollutant. An investigation of gastrointestinal absorption showed that the compound of Cd administered orally only slightly influenced absorption, retention, distribution, or pattern of excretion of Cd. Oral administration of different levels of

$^{115m}CdCl_2$ to rats showed that while the Cd dose did influence the amount absorbed through the G.I. tract and resulting tissue concentrations, the amount absorbed was not proportional to the concentration. Initial clearance of Cd was markedly influenced by the route of administration (intravenous, intraperitoneal, inhalation, and intragastric). The four routes mentioned showed 95%, 93%, 41%, and 5% retention, respectively. The biological half-life of the long retention component was greater than 175 days for all routes. Approximately 10% of the total inhaled Cd was retained, and 40% to 50% of the retained Cd was found in the lungs after inhalation exposure. Equipment and experimental techniques have been developed to study hypertensive effects and renal damage related to cadmium intake in both pigs and monkeys. A simple, reliable method to measure blood pressure of unanesthetized monkeys over an extended period of time was developed, utilizing a tail-cuff method.

Lead

Dust samples containing environmentally-bound lead were fed to rats in an attempt to determine whether: (1) lead bound in environmental samples is absorbed by blood and tissue at different rates and magnitudes than lead compounds used in previous laboratory experiments and (2) lead deposited into the environment from different sources is absorbed at different rates and in different amounts from the G.I. tract into the blood. In rats receiving a single oral dose, the Pb blood level rose for 24 hours and then decreased rapidly until at 36 days they were comparable to the levels in control rats. Three different daily dosages of lead in New York Queen's Tunnel dust samples fed to rats indicated that levels in the blood were related to levels fed and that the G.I. tract is a significant route of absorption of lead. In an effort to detect absorption differences among environmental lead dust samples collected at New York Queen's Tunnel, a Los Angeles freeway and the vicinity of an El Paso smelter, rats were fed 1.0 mg daily for 40 days. The highest blood levels were observed using the freeway dust sample, followed by the tunnel sample and the smelter sample. However, the tunnel dust was the most biologically active since it was found in greater amounts in the skeleton and organs.

Mercury

An early biological effect was demonstrated in rats exposed to a low concentration of methylmercury, using radiorespirometry. Intragastric administration caused suppression in $^{14}CO_2$ output following an injection of 1-^{14}C-glucose. This effect was cumulative when treatment was repeated 1 week later. Attempts are being made to refine this technique for utilization as a rapid screening method for other potentially-toxic compounds. Most of the changes noted in renal tissue from rats exposed chronically to mercury administered at various levels in drinking water were relatable to the aging process. Animals receiving the highest level, however, showed severe interstitial effects in the renal tubules. Additional animals would be needed, however, to relate this finding to a treatment effect since the sample size examined was small.

Toxicologic Assessment of Mobile Emissions (TAME)

Gasoline Fuel Emission Studies

Laboratory animals were exposed to emissions of a small internal combustion engine and tested for lethal responses in order to determine the comparative susceptibility of different animal species, ages, and sexes. Utilizing 1972 automobile engines and exhaust treatment exposure systems to simulate environmental atmospheres, comparative toxicity was assessed and engine exhaust emissions were characterized. Results to date indicate that fuel emissions are biologically active at realistic exposure levels.

Experimental Physiology Studies

Current hematological and blood chemistry data indicate clear cut detrimental health effects subsequent to exposure. There was a pronounced body weight loss and a definite degree of anoxia in exposed rats. It remains to be seen whether or not MMT additive accentuated the health effects. Suppression of voluntary activity observed in mice exposed to automotive engine fuel exhaust emissions was directly related to the concentration of exhaust but not to the level of carbon monoxide in the exhaust. Analysis is presently underway to determine if activity suppression is affected by the presence of a manganese additive. Changes in patterns of learned operant behavior of exposed hamsters performing a simple task were not evident.

Exposure to the raw exhaust atmosphere produces a change in the rat visual evoked potential. New methods are being developed in computer analysis techniques to more adequately determine the effects of exposure. Spinal reflexes are being tested for the screening of potential toxic agents. Spinal reflexes may be studied in isolation by stimulating and recording from the appropriate nerves to determine effects of toxicological agents. The visual evoked potential work and spinal work can be easily correlated, and the various transmitters responsible for the complex waveform of the evoked potential may thus be elucidated.

The pulmonary clearance rate in hamsters decreased after exposure to irradiated auto exhaust.

Biochemical Studies

Long chain unsaturated fatty acid films exposed to fuel emissions in vitro exhibited oxidative destruction, as was demonstrated earlier with single pollutant studies using O_3 and NO_2. Furthermore, greater changes were observed in the studies in which Mn-carbonyl was used. In the in vivo system, fatty acid composition of lung lavage showed a trend of oxidative destruction due to fuel emissions.

Since several compounds resulting from automotive fuel emissions are known to be carcinogenic in experimental animals, the determination of their biologic fate in the body following inhalation is of utmost significance. Interaction with other environmental components may have significant effects on body burden and effective biological residence time as has been shown with aryl hydrocarbon hydroxylase (AHH). Lung AHH activity has been assessed in old male hamsters exposed to diluted auto exhaust. Preliminary results indicate a significant reduction in enzyme activity and a significant difference was observed between control

and exposed animals and between irradiated and non-irradiated exposure.

Pathology

Pulmonary tissues from rats exposed to emissions showed essentially no changes other than chronic respiratory disease which was also present in the control animals. Pulmonary tissue from hamsters showed early changes and were most severe in the irradiated exhaust exposure.

RADIOCHEMISTRY & NUCLEAR ENGINEERING RESEARCH LABORATORY

The Radiochemistry & Nuclear Engineering Research Laboratory is primarily concerned with the evaluation of the environmental and public health impacts of nuclear power stations and other facilities in the nuclear fuel cycle during routine operation. More specificially, it obtains measurements to (1) identify and quantify the radioactivity and direct radiation from stations, (2) delineate the main pathways leading to population radiation exposure from these sources, (3) indicate the magnitude of population radiation exposure, and (4) present effective monitoring procedures. The resulting information is used by EPA for the establishment of radiation exposure guidelines, review of Environmental Impact Statements, organization of monitoring systems, and recommendations for measures intended to attain the lowest practicable population radiation exposures.

Because the Laboratory provides information for a variety of needs in a highly specialized area in EPA, it is supported by both the Office of Monitoring (OM) and the Office of Radiation Programs (ORP). The staff of the Laboratory reflects a coordination of disciplines in engineering, physics, chemistry, and biology. Expert assistance is provided by other EPA components, notably the Division of Meteorology, NERC-Research Triangle Park; the Cincinnati National Field Investigations Center, Office of Enforcement & General Counsel; the Eastern Environmental Radiation Facility, Office of Radiation Programs; the Division of Environmental Surveillance, NERC-Las Vegas; and the other laboratories of NERC-Cincinnati.

Necessary measurements are obtained through field studies at commercial nuclear power stations and associated facilities, in cooperation with the U.S. Atomic Energy Commission, the state environmental protection agency, and the station operator. A study begins with samplings and measurement on site to identify the radiations and radionuclides of interest, and at the station boundary to define source terms. This information is utilized in computational models to predict radiation and radioactivity levels in the environment. The model indicates critical radionuclides, pathways, and populations for detailed study, and provides the basis for selecting sampling media, minimum sample volume, indicator radionuclides, and analytical techniques. Model predictions and monitoring techniques are then experimentally tested in the station's environment. Finally, the entire study is described in published reports.

Field Studies Completed

The first part of our 5-year program consisted of field studies at four facilities typical of commercial U.S. nuclear power stations - two boiling water reactors (BWR's) and two pressurized water reactors (PWR's). The study at the first BWR was reported in FY 1971. In FY 1972, the report of the study at the first PWR was published, and studies were begun at the second BWR and second PWR. Results of these studies pertaining to radionuclide discharges, monitoring techniques, and population exposures have also been published.

A manual of radiochemical procedures for analyzing water samples at nuclear power stations is being prepared. Work toward a similar manual of procedures for environmental water samples that contain extremely low levels of radionuclides is in progress. There is also a small continuing project for determining radiation exposures of uranium miners.

The major observations from the study at the first PWR - the Yankee Nuclear Power Station at Rowe, Mass. - were as follows:

1. The station should probably be considered a good example rather than a typical source of radiation exposure because its radioactive discharges are far below normal. Total discharges of all radionuclides other than tritium to air and water were less than 10 Curies per year (Ci/yr). Approximately 1,000 Ci of tritium - a relatively low-hazard radionuclide - were discharged annually.

2. The PWR has numerous points of discharge to be considered in evaluating effluent radioactivity. In addition to the obvious sources - the reactor plant liquid and gaseous waste tanks - radionuclides are discharged without collection in tanks from the secondary-system main condenser air ejector, liquid waste and blowdown drains, and in ventilating air.

3. The only environmental radionuclides attributable to the station were present in low concentrations in sediment and aquatic vegetation near the outfall for liquid effluent.

4. Radiation exposures in the environment were too low to be measured directly. Values inferred from measurements within the station were 6 ± 3 milliroentgen/yr (mR/yr) at the nearest house and 3 ± 3 mR/yr at the nearest village due to direct radiation, 0.4 mR/yr at the station boundary due to airborne radioactive effluent, and 0.3 mR/yr to persons eating fish caught just beyond the outfall for liquid radioactive effluents. These values can be compared to the natural radiation background of 64 mR/yr measured in the environment, and the USAEC limits of milliroentgen-equivalent-man/year (mRem/yr) to the population.

5. An environmental surveillance program was recommended that is directed toward the main radiation exposure pathways and utilizes procedures appropriate to the radiation and radioactivity levels measured on-site.

Current Field Studies

The current studies are at stations newer and larger than Yankee-Rowe. Sampling programs have been emphasized that include collection of

radioactive gases and measurement of external radiation from these gases in the environment while simultaneously obtaining gas samples at the station during discharge; and collection of radioactive liquids in effluent with concentrating devices simultaneously with samples from the liquid waste tank before dilution. Radiation detection survey instruments of sufficient sensitivity are used to measure direct radiation on land and radiation from benthal deposits of radionuclides. Radioactivity is also measured in terrestrial and aquatic animals.

The detailed radiological surveillance studies at the four nuclear power stations are to be completed by FY 1974. These will be followed by several studies of specific problems and possible approaches to the lowest practicable radiation exposures at appropriate nuclear power stations. A detailed radiological surveillance study will be started at a fuel reprocessing plant.

SOLID WASTE RESEARCH LABORATORY

The Solid Waste Research Laboratory (SWRL) conducts research to develop improved methods of dealing with solid wastes from all sources. Work is directed primarily to solving problems in three areas: recovery of materials and energy from solid waste, determining public attitudes on resource recovery, and development of disposal techniques for all forms of non-recyclable solid wastes - including hazardous wastes.

Analytical and pilot-plant studies are designed to develop new waste handling or processing methods, and to develop resource recovery procedures and appropriate ultimate disposal methods for solid wastes. The SWRL uses grants, contracts, and in-house research to develop the needed information.

Scope of Solid Waste Problems

The problems of solid waste disposal are related to those of air and water pollution. Incineration, grinding, and the use of water for either transporation of solids or as a solid waste sinks, impinge upon concurrent research in air and water pollution abatement. Further, elimination of pollutants from air or water effluents at the source results in the generation of solid wastes by such processes as separation, drying, or compaction-solids which in turn require disposal. Measures to reduce pollution or dispose of waste material must be taken with full consideration of the effect upon the overall environment - air, water, and land.

The solid waste problem is concentrated in densely populated urban areas. In some cases, entire neighborhoods have degenerated, blighting much of the inner city. Refuse storage, collection, transportation, and processing directly affect some 80% of the population. The costs of waste handling, already severe, are rising. The loss of billions of tons of material as unreclaimed waste each year indirectly affects every consumer.

Land Disposal

Sanitary landfilling is the only acceptable low-cost method presently available for disposal of solid waste on the land. Although landfills can be designed to produce little or no impact on the environment, additional technical information is needed on decomposition rates and leachate and gas production in order to design efficient sanitary landfills.

Intramural activities emphasize the collection of field-scale data at an experimental landfill located in Walton, Kentucky. Leachate production rates are determined twice a week. A total of 2,500 gallons of leachate was collected during the first year of operation from 435 tons of municipal type solid waste deposited there.

An expanded series of tests, begun in August 1972, is evaluating leachate production rates and scaling factors between three 6-foot-diameter simulated cells and a field-scale 28-foot-square cell. The simulated cells will be used to evaluate a large number of variables without the great expense of quality-controlled field cells.

Under a grant to the Georgia Institute of Technology, the feasibility of modifying traditional sanitary landfill operational procedures is being studied. Leachate produced in laboratory-scale simulated landfills is recycled through the compacted waste. The objective is to achieve a high rate of anaerobic decomposition by creating a natural buffer system conducive to methane formation. Results to date indicate that the high organic acid content of leachate is reduced by this technique and decomposition is more rapidly stabilized.

Researchers at Drexel University are investigating quality and quantity of leachate produced from landfilled solid waste under precisely controlled laboratory conditions. Results indicate leachate production is highly dependent on rainfall conditions and that leachate quality is extremely variable. After 3 years of leaching, the concentration of contaminants in leachate has decreased to only one-tenth of that initially observed.

Under a research grant with the University of Wisconsin, treatability of leachates is being investigated. Preliminary results indicate leachate to be biodegradable, but chemical processing gives relatively poor removal of organics. It also produces large quantities of sludge. More extensive studies to develop treatment methodology for leachates will be conducted under a contract with the University of Illinois. The characterization of leachate samples from across the country has already begun. This characterization study will establish the first comprehensive data on the organic and heavy metal content of leachates.

Hazardous Wastes

SWRL has been gathering information for a report to Congress on National Disposal Sites for hazardous wastes. The purpose of this work is to (1) develop an inventory of hazardous waste materials; describe their effects on man and his environment; determine presently used methods for their disposal; (2) determine recommended methods of reduction, neutral-

ization, recovery and/or disposal of all hazardous waste; and (3) determine public and private attitudes toward disposal of hazardous wastes at regionally located disposal sites.

An inventory of hazardous materials has been completed and a three-volume report submitted to EPA by Booz-Allen Applied Research. Work to develop recommended methods for disposal and to determine quantities and forms in which hazardous wastes occur is being done under a contract by TRW. Profile reports on 543 materials, 133 of which are considered candidates for processing at National Disposal Sites, have been compiled to date.

Under a research contract to HumRRO Company, a national attitudinal survey is being developed. Questionnaires have been designed and preliminary surveys conducted.

A 2-year grant to the University of Florida is investigating quantities and identities of nonindustrial toxic and hazardous materials in municipal wastes.

Collection and Transport

Labor-intensive collection and transportation aspects of solid waste management constitute up to 80% of the total disposal cost. SWRL is involved in several studies designed to provide more efficient methods of collecting and transporting solid wastes.

A research grant at the University of Illinois is developing new mathematical solutions to classical postman and salesman routing problems that have direct application to the optimal routing of packer trucks for the collection and transporting of solid waste. The objective is to provide practical methods for optimizing collection truck routing for various street networks including combinations of one- and two-way streets.

A similar study by the Massachusetts Institute of Technohogy is concerned with developing mathematical algorithms whereby large urban areas can be logically divided into equal solid waste districts, each district representing one day's collection activity for a packer truck. This work also includes a separate study to establish the location of solid waste transfer and disposal facilities.

Since the use of existing gravity sewers to transport ground household solid waste holds potential as a substitute method for collecting and transporting solid waste, a research study to evaluate its technical feasibility is being conducted by Foster-Miller Associates. Results indicate that sewer transport is conditionally feasible in both straight-run lines and in many of the sewer fittings for slurries of sewage, plus up to 1% by weight of refuse.

The original technical feasibility study is being supplemented by an economic study at Curran Associates to establish economic feasibility data. The Curran study is a computerized economic sensitivity study involving systems analysis of alternative methods within the wet pipeline approach. Should the Curran study indicate strong economic and social impact advantages in the pipe transport system, further technical studies on a pilot plant and demonstration project scale would be recommended.

Processing

In many plants processing municipal refuse, the expense for grinding the refuse constitutes the major cost. Because basic data on refuse size reduction mechanisms and associated equipment design are not available, research is being conducted by SWRL to obtain these data. Availability of this information will allow more efficient utilization of existing grinding equipment and provide design information for constructing improved grinders. These factors could help to significantly reduce the grinding cost associated with processing refuse. Fundamental data on the size distribution of ground refuse and compression strength of various refuse components have also been measured.

Separation

Automatic separation of the various constituents normally found in municipal refuse is being approached through the development of sensing devices which operate with infrared absorptivity or reflectivity, reaction to impact, or electrical conductivity. Once the sensors are perfected, a coding device will be used to effect the mechanical removal of the selected material from the refuse. Wavelength spectra for paper, some plastics, cans, and glass have been identified so far. Assembly of mechanical handling equipment is nearing completion.

An intramural pilot plant to study automatic sorting and separation of municipal refuse on a dry basis has been designed. The pilot plant will investigate promising resource recovery hardware technology and dry separation processes.

Incinerators

SWRL research on incineration processes has contributed to a better understanding of combustion processes and incinerator design. Combustion reactions above the fuel bed were found to be a function of the degree of mixing of the overfire air. It was also found that organic pollutants could be significantly reduced by the efficient use of overfire air jets. One study investigated burning rate as a function of underfire air produced data useful in establishing new design criteria as well as combustion control information. Work is underway to establish the extent and mechanism by which corrosion of incinerator metal occurs. Once the corrosion reaction is known, steps can be taken to circumvent it or slow its progress.

These advances have provided the basis for more refined research projects designed to advance the state-of-the-art of incinerator design and operation. An intramural incinerator designed to simulate municipal incinerators has been installed which has the capability to study combustion processes and incinerator effluent stream contaminants.

CPU-400: Resource Recovery

The major resource recovery project being undertaken by the Solid Waste Research Laboratory involves an elaborate process called CPU-400 which burns the combustible component of refuse and uses the hot gas stream to drive a turbine for the generation of electricity. The CPU-400 pilot plant is in the final development phase and system performance is being evaluated using a series of long-duration runs of operation.

Recycling: Resource Recovery

Research conducted on the recycling of solid waste has also concentrated on the conversion of waste cellulose, rubber, plastic, and glass into useful products. Protein has been successfully produced from cellulosic waste using fermentation techniques. Under a research grant with Louisiana State University, results from a small batch-type fermentor reproduced in a larger continuous-type unit will help to evaluate the economics of the process. Louisiana State University has also developed techniques to separate and purify the microbial protein.

Intramural work to evaluate physical and chemical pretreatment of wastes to enhance the rates of cellulose utilization indicates that a sensitized photodegradation process and a chemical pretreatment process are most effective. Studies by Gillette Research Institute demonstrated that the degree of polymerization of cellulose is significantly reduced by the photochemical process.

A research grant with Worcester Polytechnic Institute indicates that a low pressure hydrogenation process offers potential for converting cellulosic waste into a high grade fuel. The process is technically feasible but is not presently economically attractive. In a research study on chemical conversion of wood and cellulosic waste, three fractions were isolated from the pyrolysis of cellulosic material which contain products that could be used as fuels.

Two projects have demonstrated that waste rubber can be successfully recycled into useful products. A contract with Hydrocarbon Research, Inc., demonstrated the technical feasibility of a hydrogenation process for utilizing waste rubber. Ground rubber tires can be converted to fuel gas, naphtha gas, oil, and carbon black in a hydrogenation reactor operating at temperatures from 660 F to 850 F with hydrogen at partial pressures of 500 to 2,000 psig. Favorable economics have been projected for a plant processing 1,000 tons per day of ground waste rubber.

Waste rubber was also recycled for use as a road dressing. Water emulsions of blends of waste rubber, asphalt, and coal tar were applied to high-traffic areas of selected parking lots for testing. This work is being conducted by Battelle Memorial Institute under a research grant on scrap tire utilization in road dressings.

In another project studying the use of waste glass as a paving material, laboratory and field tests on asphalt containing waste glass aggregate demonstrated the suitability of these wastes for paving materials.

Systems and Behavioral Studies

The major emphasis of the systems and behavioral activities was directed towards (1) determining the economic effects of various government policies on selected solid waste problems; (2) determining the attitudes of the nation's citizens regarding solid waste and resource recovery; and (3) developing a framework for the Laboratory's future soft science solid waste research program.

The extent of solid waste problems caused by beverage containers and abandoned automobiles has been examined and

possible strategies have been developed for easing these problems. The beverage container study concluded that the container's major area of environmental insult is in the form of litter and recommended that a low tax (0.5 to 1.0 cents per container) should be placed on beverage containers with the revenues used for more frequent litter collection. The abandoned automobile study concluded that the problem was getting worse, especially in rural areas, and that a more active role must be taken by the public sector to ease the problem. Recommended strategies included a disposal certification program for automobiles and a state-subsidized collection program for rural areas.

A major effort was undertaken by the International Research and Technology Corporation to determine how much combustible solid waste is generated in the country and what technologies and strategies should be supported by EPA to reduce the problems caused by combustible solid wastes. Certain feasible strategies were identified for recovering resources from combustible solid wastes. The preferred strategy calls for imposition of an excise tax to subsidize municipalities that process wastes according to approved waste disposal and resource recovery procedures.

A study analyzing the effects of Federal Government regulations and policies on solid waste generation concluded that although some Federal agencies do influence the generation and reclamation of solid waste, surprisingly few agency policies have a major effect on generating solid waste or inhibiting the recovery of resources. The recommendations for improving the Federal role in resource recovery included (1) revising Federal tax treatment of virgin materials versus secondary materials, (2) clarifying the Tax Reform Act of 1969 to include solid waste as well as air pollution and water pollution control facilities for favored tax treatment, and (3) including the consideration of solid waste generation in Environmental Impact Statements.

A national survey of housewives was made to determine their feelings about solid waste problems in general and about programs to reduce such problems. Findings indicate that housewives have only a fragmented understanding of solid waste problems and their solutions. Housewives are willing and eager to reduce their solid waste impact and feel they have the responsibility to do so, but they see a need for government to provide them with the necessary information on what to do, and how.

Other projects undertaken during the year included (1) in-depth analyses of the ferrous metal and aluminum industries, (2) studies to develop an economic framework for policy analysis, (3) extensive analysis of the effects of Federal purchasing policies on solid waste problems, and (4) development of criteria for regional solid waste management planning.

WATER SUPPLY RESEARCH LABORATORY

The Water Supply Research Laboratory performs health-effects studies necessary to establish standards for drinking, recreational, and food-growing waters, and develops the microbiological, chemical, and engineering technology necessary to ensure the attainment of drinking water standards and the maintenance of satisfactory quality throughout the distribution system. The Laboratory also provides analytical and technical services to EPA Regional Offices and the Office of Air and Water Programs.

The WSRL was instrumental in revising the Public Health Service Drinking Water Standards, as well as an appendix with background information. The revised standards were used as a partial basis by the National Academy of Sciences (NAS) Panel appointed to revise the Raw Water Criteria for Public Water Supplies. Similar information and liaison was given to the NAS Panel revising the Criteria for Recreation and Aesthetics.

Health Criteria Studies

Unknown Organic Contaminants

Toxicological studies necessary to support a drinking water standard for general organics have long been hampered by the lack of an acceptable test material from drinking water. Reverse osmosis now appears to be a promising method for concentrating most organics from drinking water without altering their character. Animal experiments using some of these concentrates should identify a basis for an organic limit in drinking water.

Inorganic Chemical Contaminants

Proposed mercury standards of 2 microgram/liter necessitated measurement of mercury concentrations in many drinking waters throughout the country. This study showed that the proposed standard was reasonable and indicated no imminent health hazard from mercury in drinking water. Controlled studies are being made on experimental animals: (1) to determine the lowest dose of methyl mercury in drinking water that will produce biochemical lesions in the central nervous system, and (2) to ascertain whether methyl mercury in drinking water will produce synergistic toxicity of other environmental chemicals.

Home water samples were obtained from families participating in a New York air pollution investigation under the Community Health and Environmental Surveillance Studies. An exposure gradient for copper and zinc in water was discovered in this study, and lead was found in several samples taken in New York City during a Community Water Supply Study.

Some public water supplies have nitrate levels exceeding the Drinking Water Standards (2% in Community Water Supply Study). Actually, the problem is most acute in individual private well systems (70% in some isolated counties), but few cases of methemoglobinemia occur. Field studies of infants in California and Illinois showed a subclinical effect, elevated methemoglobin in infants using water at 90 mg of nitrates per liter. This effect occurs at or above the standard 45 mg/l depending on use of powdered

formula, boiled water, and susceptible babies under 3 months of age. Because the Russian literature reported effects in older children at high levels, the WSRL made a study in Washington County, Illinois, where only a slight effect among pre-schoolers was found.

Infectious Waterborne Disease

A WSRL tabulation on waterborne disease outbreaks is maintained, and investigative assistance is available to communities to determine the cause of the outbreaks.

A 10-year review of outbreaks showed that 46,000 cases of illness involved occurred in 130 separate outbreaks. The use of untreated ground water for public supplies caused over half of the reported waterborne diseases. Most infectious hepatitis was not a treatment problem, but was caused by cross-connections or back siphonage into the distribution system. The past downward trend has leveled off and there is now about one waterborne disease outbreak per month in the U.S.

WSRL has been striving to improve analytical methods to identify viruses in water. A survey of the persistence of virus through several public water treatment plants is underway.

Control Technology Studies

Removal of Trace Organics and Taste and Odor

Historically, water treatment plant operators were unable to measure the organic content of their drinking water except by measuring the qualitative parameter of threshold odor. A miniaturized sampler and an improved carbon extraction procedure for determining these organics (carbon chloroform extract (CCE) and carbon alcohol extract (CAE)) were developed and field tested. This method will permit most water treatment plants to measure significant organic content of their finished drinking water, including taste and odor producing components.

Monitoring of general organic content and odor was conducted at four field sites using granular activated carbon as a combination filtration and adsorption media. This work showed that organics break through activated carbon beds long before taste and odor materials, which may indicate the necessity for altering the reactivation cycle of granular activated carbon beds, if their purpose is the removal of most organic materials having health significance.

Removal of Turbidity and Specific Particles

Two parallel 1 gpm water treatment pilot plants are now under construction. These fully-instrumented plants will be used to study filtration, granular carbon adsorption, and ozonation (among other processes), and to confirm batch treatment results in a continuous flow plant.

Removal of Trace Metals and Nitrate

Laboratory studies with both inorganic and methyl mercury at environmental levels showed that if sufficient turbidity is present to adsorb all of the mercury, coagulation and sedimentation will remove it. Precipitative softening removed some inorganic mercury, but not methyl mercury. Both mercury forms were removed effectively by activated carbon. Similar studies are underway on barium, arsenic, and selenium.

Selective ion exchange resins can remove nitrate from drinking water, but studies are underway to determine the interfering effect of highly mineralized water (containing silica, in particular) on this process.

Chemical Quality Deterioration

Under contract with the National Sanitation Foundation, an automatic portable monitor is being developed to measure temperature, dissolved oxygen, pH, conductivity, nitrate, hardness, free and complexed fluoride, chloride, turbidity, free and combined chlorine residual, cadmium, lead, and copper. Field testing of this device is now underway.

Contaminants and Additives in Drinking Water During Storage

A protocol was established for the study of bacterial dynamics in reservoirs through bacteriological, physical, and chemical analyses. Special equipment for vertical and bottom sampling, and for survival studies of both indicator and pathogenic organisms is being constructed. Preliminary studies of indicator organisms in thermally stratified reservoirs is being analyzed to determine the best sampling locations and best techniques for obtaining valid bacteriological data.

Bacteriological Quality Deterioration of Potable Water

There is a need for rapid assessment of the sanitary quality of water for emergency or temporary potable water supplies, at bathing beaches whose quality may have deteriorated following storms, and where shellfish-growing areas are subjected to sewage pollution. A procedure adaptable to true emergency situations, and utilizing readily available equipment and materials, was tested at 14 Lake Michigan beaches and the results are being evaluated.

Bottled water is being studied to obtain data on the relationship between bottled water quality and the bacteriological quality of its source. Storage studies compared refrigerated and non-refrigerated bottled waters and indicated that low-temperature storage apparently retards development of high bacterial populations. In general, the quality of pasteurized bottled water is better than in ozonated or U.V. irradiated waters. Any of these treatments produced a bacteriological quality better than bottled water subjected to ion exchange systems.

Adequate disinfection of newly laid or repaired water mains has long been a problem. Distribution-line disinfection studies involving comparative effects of chlorine and potassium permanganate were intiated using test sections of simulated water pipe and contaminated tap water and the addition of clay, humus, and sand slurries. Preliminary studies uncovered some experimental problems; e.g., using thiosulfate to dechlorinate the tap water reduces permanganate.

Microorganisms in Drinking Water

Chlorination studies on over 30 virus species showed that effective disinfection time for low-temperature conditions ranged from less than 3 minutes to more than an hour, depending on the species of virus.

Studies are being conducted on turbidity interferences to disinfection with chlorine. Waters with turbidities at or near the Drinking Water Standards and containing natural viruses are

being disinfected with chlorine and the inactivation rates are being compared to similar samples without turbidity.

Safety of Products

The safety of products used in connection with water supplies is an urgent problem now being evaluated. Such products include chemical additives, paints, liners, etc. A more specific example is the monomer content of polyacrylamide coagulant aids.

A cooperative study with the City of Dallas and Texas A&M University is measuring the metal content of the tertiary effluent of an advanced waste treatment plant.

Safe Recreational Water Quality Criteria

A program for developing criteria for recreational waters includes a series of epidemiological-microbiological trials at bathing beaches - intitally salt water beaches in New York City - to relate the incidence of illness among swimmers to some microbiological, chemical and/or physical indicators of water quality. A preliminary test of the methodology is planned for the summer of 1973. Preliminary demographic and behavioral data were gathered at New York City beaches during this past summer. In addition, an evaluation of existing enumerative methods for a large number of potential bacterial indicators and pathogens was conducted. Most of the methods were found to be deficient for use during the trials at the New York City beaches. A membrane filter (MF) method for the enumeration of Pseudomonas aeruginosa was developed. Significant progress has been made toward the development and evaluation of MF enumerative methods for fecal streptococci, Staphylococcus aureus, Aeromonas hydrophila, Klebsiella sp., and the component parts of the coliform population.

In cooperation with the Corvallis, NERC, water samples collected as part of the Lake Eutrophication Study were examined for Naegleria gruberi. This ubiquitous amoeba is the cause of amebic meningoencephalitis, a universally fatal but infrequent disease (22 reported cases since 1966) associated with water-based recreation.

Technical Assistance

The Water Supply Research Laboratory supplies technical assistance to other elements of EPA as well as to states and other Federal Agencies. These activities fall into the following major categories:

- evaluation of state laboratories
- surveillance of interstate carrier water supplies
- assistance to the States in surveillance of their water supplies
- technical assistance to EPA Regions, states, and other Federal agencies
- surveillance of water supplies of National parks and other Federal installations
- surveillance of bottled water.

Other technical assistance activities include the development of special analytical methodology for water supplies. For example, a procedure has been drafted for the determination of 19 different metals by atomic adsorption spectrophotometry and for the wet chemical determination of mercury for inclusion in the 14th Edition of "Standard Methods for the Examination of Water and Waste Water."

FEATURE ARTICLES

CAM-1: USING ENZYMES TO DETECT INSECTICIDES

Introduction

The rapid monitoring and accurate detection of certain cholinesterase-inhibiting substances in watercourses are critical. These materials, which include insecticides of the organophosphate and carbamate types (Azodrin, DDVP, dimetilan, malathion, parathion, paraoxon, and Sevin), interfere with physiological and neurological functions by inhibiting the action of cholinesterase-type enzymes. They are toxic to living things, particularly to humans.

The development of CAM-1, a fully engineered prototype model of a system for using enzymes to detect organophosphate and carbamate pesticides in water, represents a significant technological advance in the field. The device is the first instrument to successfuly use an immobilized enzyme product for automatically monitoring water supplies for the presence of cholinesterase-type inhibitors. CAM-1 is sensitive enough to prevent the poisoning of humans and animals by a wide variety of organophosphate and carbamate insecticides. Although it was specifically designed to monitor the concentration of these types of insecticides in water supplies, the device can also be used to check the quality of industrial plant effluents and to detect spills of the types of pesticides to which it responds.

CAM-1 was developed by the Midwest Research Institute (MRI) in Kansas City, Missouri, under EPA's Hazardous Materials Spills Research Program. The project (EPA Contract No. 68-01-0038) was sponsored by the Edison Water Quality Research Laboratory of the National Environmental Research Center in Cincinnati, Ohio.

In 1972, CAM-1 received national recognition at the IR-100 annual competition, where it was selected from several thousand entries as one of the 100 most significant advances in applied science and technology. The device was included in the month-long IR-100 display at the world-famous Museum of Science and Industry in Chicago (Figure 3). Requests for further information about CAM-1 have been received not only from interested parties in the United States, but also from scientists and engineers in 29 foreign countries.

A cholinesterase is an enzyme that causes the hydrolysis (splitting) of esters of choline. Cholinesterase is essential to the proper functioning of the human nervous system. Certain organophosphates (which are produced by the reaction of phosphoric acid and alcohols) inhibit or are antagonistic to action of the enzyme cholinesterase. Thus CAM is an acronym for "cholinesterase antagonist monitor," and its action can be regarded as that of a toxicity meter for certain materials.

Previous attempts to use cholinesterase-type enzymes for pesticide detection generally depended on adding the enzyme to the suspected water and then determining whether the enzyme retained the capacity to hydrolyze a material (substrate) that was subsequently added. Frequently, the determination was made by spectrophotometric means. The procedure was time-consuming

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Figure 3. Display of "CAM-1" at the Museum of Science and Industry, Chicago, September-October 1972

and unsuitable for the rapid alarm required to signal the presence of toxic levels of organophosphate pesticides in water supplies. Furthermore, the enzymes and substrates were moderately costly and were required in considerable quantities.

Design and Operation of CAM-1

Two technological advances were needed to accomplish the creation of the CAM-1 system: (1) development of techniques for bonding an enzyme to a carrier material so that the enzyme is active, conserved, and readily available, and (2) the development of some rapid, convenient, accurate method for detecting hydrolysis of the substrate. A breakthrough came with development of techniques for bonding an enzyme to a carrier; MRI bonds the enzyme either to cotton or to polyurethane foam. The process roughly resembles dyeing with a mordant. MRI developed an in-place, electrochemical method for determining the extent or degree of hydrolysis, which is an inverse measure of the inhibition of the enzyme (or, consequently, of the toxicity of the water being tested).

After these two major obstacles had been overcome, a flow-through system could be engineered. In this system, water suspected of containing organophosphates is passed through a pad dyed with the enzyme. (Pesticide in the water reacts with, and thus inactivates, immobilized enzyme molecules to an extent that is proportional to the quantity of pesticide passed through the cell and at a rate that is proportional to the concentration of the pesticide in the water.) The water flow (500 ml/min) is diverted, and a small amount of substrate solution (1 ml) is added to the pad. When the enzyme has not been inhibited by the toxic materials in the water, the substrate will be hydrolyzed. When there has been an inhibition of the cholinesterase, however, the rate of hydrolysis of the substrate, as well as the quantity of material hydrolyzed during the operating time period, will decrease.

The critical element of the CAM-1 design is a pad of immobilized cholinesterase, which is sandwiched between perforated platinum electrodes. The electrode unit is about 8 mm thick and 1 cm in diameter. Water is pumped through the pad for 2 min; during the third minute, air and an enzyme-active reagent or substrate solution is forced through the cell (the enzyme is equine serum cholinesterase (I.V.B. 3.1.1.8), and the substract is 2.5×10^{-4} M butyrylthiocholine iodide in 0.08 M TRIS buffer at pH 7.4). Finally, during the last half minute of the complete 3-min cycle, a battery is connected across the platinum electrodes and a small current (2μA) flows through the cell. When the substract is being hydrolyzed at the maximum rate (that is, when the cholinesterase has not been inhibited by toxic substances in the water), the voltage across the cell will be significantly lower than when the enzyme has been inhibited. The voltage registers on a digital voltmeter and on a small strip-chart recorder. (The normal voltage for a fresh pad is about 100 mV; the voltage across an inactivated pad is about 500 mV.)

The explanation for the voltage change has not been sought in detail, but the change does not arise from a mere alteration in conductivity. There is evidence that both a redox potential change and a depolarization effect are involved. On hydrolysis, the substrate produces a hydrosulfide, which is

readily electrooxidized to a disulfide. The redox potential of such a hydrosulfide-disulfide half-cell is of the proper order. As the immobilized enzyme becomes inactivated, the concentration of hydrosulfide available for oxidation is decreased, and the potential of the couple increases toward that of the oxygen electrode potential.

The electronics are designed so that a previous cell voltage reading can be stored in the memory of a small, built-in computer and compared with a new voltage reading. When the new voltage is greater than the previous voltage by a preset value (which can be dialed into the CAM-1 device), an alarm sounds.

With time, the enzyme pad loses some of its activity, particularly because of inactivation by toxic substances, but also as a result of the slow washing out of the enzyme. In normal operation, a pad is good for a day. A pad-change voltage can be dialed into CAM-1, so that when the voltage exceeds a preset value, the cell is automatically opened and the pad changed. The device holds 10 new pads. Thus, CAM-1 operates for several days without attention, unless organophosphates occur in the test water in such concentration and duration that the pad supply is used up.

CAM-1 is designed so that is can be operated in tandem with a second unit, but half a measurement cycle (1-1/2 min) out of phase. This arrangement reduces the minimum alarm time and provides, in addition, complete sampling of the water; there is no "dead" time. The arrangement with two units in tandem is self-comfirmatory.

In a limited series of laboratory experiments, CAM-1 consistently gave an alarm at the concentrations of pesticides shown in Table 4. The alarm threshold level was set at 15 millivolts, but a detection limit 2 or 3 times smaller (5 millivolts) can certainly be used with the existing device.

TABLE 4. ALARM RESPONSE OF CAM-1 TO SELECTED INSECTICIDES

Type of insecticide	Response concentration ppm	LD_{50} rats mg/kg
Organophosphate:		
Malathion	16	1,640
Parathion	5	56
DDVP	1	56
Paraoxon	0.1	4
Carbamate:		
Sevin	50	560
Dimetilan	10	64

Toxicities are given for reference. A rough correlation exists between toxicity and the CAM-1 response levels; but it should be noted, for example, that a rat weighing 1 kg would have to imbibe more than 10 liters of water with a parathion concentration of 5 ppm to accumulate a toxic dose (56 mg/kg of body weight) of the pesticide (5 ppm = 5 mg/liter = 5 mg/kg water).

Future Developments

The next steps in the development of CAM-1 will be to determine whether any nontoxic materials give alarm signals and to measure the actual threshhold limits for a wide variety of pesticides. In principle, the CAM-1 system could also be developed to use enzymes other than cholinesterase. The following represent a few examples of enzymes and the substrates that are antagonistic to their action: catalase (cyanides, azides), urease (fluorides, formaldehyde), lipase (aldrin, lindane), hexokinase (2,4-D and 2,4,5-T), and cytochrome oxidase (cyanides).

CAM-1 can be produced in a simplified, more portable version that will be suitable for rapid detection of cholinesterase antagonistic pesticides under field conditions.

DEVELOPMENT OF GAS CHROMATOGRAPHY/MASS SPECTROSCOPY

Many of the standard techniques of chemistry that have provided very valuable information in flagrant pollution situations suffer severe limitations. They may be slow, expensive, relatively insensitive to very small quantities, or unable to generate really definitive information. As a result, environmental researchers have begun to turn to a new interdisciplinary technique, computerized gas chromatograpy/mass spectrometry (GC/MS).

Like any automated method, computerized GC/MS does not reduce the need for skilled manpower. Indeed, it requires highly skilled interdisciplinary teams of spectroscopists, analytical chemists, electronics engineers, and lab minicomputer specialists. Its major advantage is that it increases enormously the capabilities of a staff of fixed or limited size.

A computerized GC/MS system was installed at the Analytical Quality Control Laboratory (AQCL), in September 1971. Since that time, it has been used in a variety of methods development projects, including development of a procedure for analysis of polychlorinated biphenyl compounds in the presence of chlorinated hydrocarbon pesticides. Use of the GC/MS system in the latter case eliminates the need for laborious and time-consuming chromatographic separation.

Seventeen complete GC/MS systems, valued at about $1.7 million, were installed and operating in EPA labs in the last 2 years. The systems are employed in six regional surveillance and analysis labs, two national field investigations centers, and at various NERC laboratories in Cincinnati, Ohio, Corvallis, Ore., and Research Triangle Park, N.C.

An EPA mass spectrometer users group was organized by AQCL to promote the informal exchange of technical information among EPA labs using computerized GC/MS. Effective use of this sophisticated equipment will provide enforcement officials a significant tool for analysis of organic pollutants.

Design

The three functional parts of the systems are as follows:

1. The gas chromatograph. This device is very well established as a powerful separation tool for complex mixtures of organic compounds.

2. The mass spectrometer. Conventional GC detectors provide too little information content and have been replaced by the mass spectrometer, which is the only GC detector used. Like conventional GC detectors, it is very sensitive, but it provides a response that carries a great deal of information characteristic of the molecular structure and composition of organic compounds. This information is displayed as a histogram by a plotter.

3. The minicomputer. The hookup between production and utilization of information is made possible by the minicomputer. Unlike conventional GC detectors, the mass spectrometer is not run continuously in noncomputerized systems because it would generate far more information than could be

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assimilated and used. The minicomputer takes all this information in stride and controls the whole operation in its spare time. Personnel are thus freed to do productive tasks like data interpretation.

Methods Development

The manufacturers of the GC/MS equipment provide basic operating instructions, of course. But since they manufacture equipment for use in a wide variety of applications (from biomedical research to identification of drugs in racehorse urine), they cannot possibly provide detailed methods for any one of them. Therefore, one project of NERC-Cincinnati AQCL research program is to develop detailed methods for the use of computerized GC/MS systems in EPA laboratories. Needed methodology includes calibration and quality control techniques, data interpretation aids, and revised and updated minicomputer programs to expand capabilities.

The problem of identifying and measuring specific organic compounds (e.g., DDT) that contaminate the environment has concerned environmental research scientists for many years. The huge number of potentially harmful or toxic compounds that are possible generally precludes the development of a specific analytical method for each. Therefore, general approaches based on slight differences in solubility, chromatographic behavior, and spectroscopic measurements have been developed and widely used.

Conclusion

Identification of noxious pollutants at the parts per billion level, with a high degree of confidence in the result, have become nearly routine in a few EPA laboratories since GC/MS systems have been installed. What was once a nearly impossible task for a staff of 100 working for 6 months can now be accomplished by three people in a few hours.

LAKE RESTORATION BY PHOSPHORUS CONTROL: SHAGAWA LAKE, ELY, MINNESOTA

Many small communities in the United States are located on inland lakes that have become polluted and overly fertilized by poorly treated sewage. Shagawa Lake, which extends within the city limits of Ely, Minn., is a graphic example. The lake has a long history of producing nuisance algal blooms in the summer, although advanced eutrophy is not common in this geographical region.

The major source of phosphorus input to Shagawa Lake is the wastewater treatment plant discharge of the city of Ely. Ely has a resident population of about 5,000, but this figure is typically inflated to 10,000 during the summer tourist season. The city has been discharging sewage in to the lake since 1901, but only since 1954 has secondary treatment of the waste been provided.

Except for the city of Ely, the vicinity of the lake is sparsely populated. Most of the surrounding land is covered with deciduous and coniferous forest. No significant amount of agriculture is carried out in the area, and there is very little industry. The primary surface input is via Burntside River, which is fed by oligotrophic Burntside Lake. The Ely wastewater plant effluent thus represents essentially a point source of phosphorus and other nutrients. Circumstantially, it appears that Shagawa Lake may have been significantly advanced in its eutrophic state because of its history as a receptor for municipal sewage effluent.

The secondary treatment facilities of the city handle an average daily flow of about a million gallons and consist of a primary clarifier, a high-rate trickling filter, a secondary clarifier, and a chlorine contact chamber. This type of plant is traditionally ineffective in removing phosphorus. Studies conducted over a period of several years by EPA's National Eutrophication Research Program (NERP) indicated that removal of nearly all of the phosphorus from the municipal treatment plant effluent would restore Shagawa Lake to a much improved condition within a relatively few years. The studies were performed using (1) a 20,000-gal-per-day, advanced waste treatment pilot plant fed with Ely trickling filter plant effluent and (2) in situ bioassays conducted in three 150,000-gal, floating test basins.

Shagawa Lake itself has a surface area of 2,500 acres, an average depth of 22 ft and a maximum depth of 48 ft, a mean volume of 15 billion gal, and a calculated retention time of less than 1 year. This short retention time, the virtual absence of diffuse sources of nutrients, the existence of only one significant point source of phosphorus, an inflow of oligotrophic water, and the reasonably small size of the lake and city made this a nearly ideal situation in which to carry out a lake restoration study.

Restoration of Shagawa Lake is especially important from a regional viewpoint because its water flows into several other oligotrophic streams and lakes, including Canadian border waters. The lake is located about 260 miles

north of Minneapolis-Saint Paul and about 16 miles south of the Canadian border--in the heart of a vast lake region at the edge of a designated wilderness area of the Superior National Forest. Restoration would also be of great value to the city of Ely, since the lake in its present condition has lost its great recreational and economic value. These factors and the national impact that a successful lake restoration demonstration would have on implementing phosphorus removal technology contributed to the joint decision by EPA and the city to proceed with full-scale phosphorus removal at Shagawa Lake.

Project Objectives

Two EPA research, development, and demonstration grants were awarded to Ely, the first in February 1971 for design of the full-scale facilities, and the second in June 1971 for plant construction and operational supplies, chemicals, and utilities. At the time of these grant awards, Ely was under stipulation from the State of Minnesota to reduce the phosphorus concentration in its plant effluent to 1 mg per liter by May 1973. The results of the pilot studies conducted at Ely indicated, however, that a greater degree of phosphorus removal was necessary to demonstrate measurable restoration of Shagawa Lake over a relatively short period of time. A phosphorus concentration of 0.05 mg per liter of effluent was recommended by Dr. A. F. Bartsch, Director of the National Environmental Research Center (NERC), Corvallis, Ore., as a more realistic level for achieving the desired degree of restoration in a 3-year period.

Consistent production of municipal sewage plant effluent with a phosphorus level of 0.05 mg per liter is, however, the most ambitious known phosphorus removal of its kind in the world. The tight control required to achieve such an objective and to provide the substantial improvement in organics and suspended solids removals stipulated for Ely by the State of Minnesota dictated the design and construction of a tertiary operation to supplement the existing trickling filter plant, rather than an in-process upgrading of the existing facilities. Construction of these tertiary facilities was essentially complete in late 1972, and the first few months of 1973 have been devoted to plant startup, process checkout, and equipment adjustment.

Plant Design

The tertiary treatment facilities are designed for maximum phosphorus removal and include flow equalization of effluent from the trickling filter plant, two-stage lime clarification with intermediate recarbonation, dual-media filtration, and final pH adjustment and disinfection. The chemical sludges produced are dewatered in a gravity thickener followed by vacuum filtration and final disposal in a sanitary landfill. A flexible chemical dosing system is provided to enable several types of coagulants and polymers to be added as necessary at multiple feed points. Facilities for dosing powdered activated carbon to the existing secondary clarifier to improve soluble organic carbon capture are also provided. All of the above equipment is housed in a new combined laboratory, control, and tertiary process building. The individual process units are sized for an average flow rate of 1 million gallons per day, with a capacity factor of 1.5

Both the first- and second-stage lime clarifiers have a diameter of 55 ft and are of the sludge-recirculation, solids-contact type. Each of the four effluent filters is a 12-ft-diameter unit equipped with anthracite-over-sand media and automatically controlled, air-scour gravity backwash. The sludge thickener has a diameter of 26 ft and a side-wall liquid depth of 15 ft; it is equipped with a center-drive sludge thickening rake. The vacuum filter is of the continuous-fabric media type, with a drum diameter of 6 ft and a length of 8 ft.

Sufficient lime is added to the first-stage contactor to raise the pH to approximately 11.8 (lime dosages to accomplish this have averaged about 300 mg of CaO per liter during plant startup). This procedure converts virtually 100 percent of the soluble phosphate to insoluble calcium phosphate. Carbon dioxide is utilized in the second-stage contactor to lower pH to 9.5-10.0 and allow precipitation of excess causticity as calcium carbonate. Small doses (5-10 mg per liter) of ferric chloride and aluminum sulfate added to the second-stage contactor are being evaluated as to (1) their capacities for precipitating trace quantities of soluble phosphorus still remaining in the wastewater at that point in the treatment sequence, and (2) their coagulative value in aiding colloidal solids capture in the dual-media filters. After filtration, final pH adjustment to approximately 7.5 is accomplished with sulfuric acid.

To assure complete control of phosphorus entering the lake and to provide for the maximum beneficial impact to the lake, it was necessary to install channel collection and pumping facilities to intercept septic tank runoff from 120 homes that previously drained directly in to Shagawa Lake. This drainage is now pumped to the headworks of the treatment plant, thus preventing a significant source of extraneous phosphorus from entering the lake untreated.

Administration

Administration of grant activities and technical assistance related to treatment processing is provided routinely by the National Environmental Research Center (NERC), Cincinnati, Ohio. Under an agreement with the city of Ely, EPA is authorized to operate both the secondary and tertiary treatment facilities during the 3-year demonstration period (terminating in April 1976), during which it is anticipated that Shagawa Lake will exhibit first a decline and then a reversal in its current accelerated aging process. NERC-Cincinnati is providing 17 plant operators and plant laboratory technicians, plus a resident plant engineer for the duration of the project. The project director and personnel for carrying out lake sampling, lake measurements and analytical determinations, and documentation and evaluation of lake data are provided by NERP (administered by NERC-Corvallis). The city is contributing one Class B operator and two operator helpers.

No previous demonstration of lake restoration has been attempted based on the premise that it can be accomplished by removing a critical nutrient from municipal wastewater and allowing the treated wastewater to continue flowing into the lake. Preliminary data generated during plant startup indicate that the effluent residual objective of 0.05 mg of phosphorus

per liter can be continuously met with careful and dedicated operation and control. The prognosis for a successful demonstration project is encouraging. Both the continuing performance of the Ely treatment facilities and all progress made in restoring Shagawa Lake will undoubtedly be closely followed by sanitary engineers and regulatory groups alike.

NATIONAL ENVIRONMENTAL INFORMATION SYMPOSIUM: AN AGENDA FOR PROGRESS

For some time there has been a widening interest in and demand for improved organization, processing, and dissemination of environmental information. In response to this growing concern, the National Environmental Information Symposium (NEIS) was held in Cincinnati, Ohio, on September 24-27, 1972. This symposium, sponsored by EPA and hosted by NERC-Cincinnati, was the first general convocation of the environmental information community. It grew out of the conviction that environmental problems could be more easily solved if the information required were readily available to all segments of society. More than 1,700 participants represented a substantial portion of the community of producers and users of environmental information in the United States. In addition, about 50 international observers were present. The program was enriched through the participation of about 125 exhibitors, who gave detailed descriptions and demonstrations of the information sources and services available. In cooperation with other Government agencies, EPA undertook to organize the Symposium with three basic purposes:

- To bring together concerned citizens, trade associations, professional societies, and governmental bodies to share ideas, interests, and common concerns.
- To identify specific directions that governmental and private organizations could take to strengthen coordination and cooperation and to improve environmental information exchange.
- To provide a forum for producers and processors of environmental data to demonstrate the most up-to-date techniques, methods, and equipment to users in the fields of information science and systems.

The proceedings of the National Environmental Information Symposium are being issued in two volumes. Volume 1 contains a statement of the background and purpose of the Symposium, a summary of participant comments and recommendations (gleaned from verbal and written communications with members of the Symposium committees), and the full text of the user panel reports. Volume 2 includes the papers presented by the general session speakers, introductory statements by the moderators, papers presented by the session speakers, and any reports submitted from the evening forum sessions. The proceedings will be published and distributed by the National Technical Information Service, U.S. Department of Commerce.

A NEW FACILITY FOR NERC-CINCINNATI

Groundbreaking ceremonies for the National Environmental Research Center's new facility near the University of Cincinnati were held on June 28, 1972.

Land for the new EPA facility was donated to the Federal Government by the city of Cincinnati. The ceremony, whose participants included, Julie Nixon Eisenhower, the Administrator of EPA, and other EPA, State, and City officials, climaxed more than 10 years of planning for the multidisciplinary environmental center. In 1972, the Director of NERC-Cincinnati and the president of the University of Cincinnati, signed an "Agreement of Mutual Assent," which identified areas of mutual interest and concern to the University and to EPA.

The cost of the construction contract, awarded in November 1972, is about $21 million. Work on the center began in December. After completion, which is scheduled for May 1975, it is anticipated that all EPA personnel in Cincinnati will consolidate in just two facilities--the new center and the Robert A. Taft Laboratory. A study is presently in progress to identify the programs that will be housed in each of these buildings.

The new facility will be a 10-story structure, rising eight stories above grade in the southeast sector of an almost rectangular, 20-acre tract. The site is strategically located between the main campus and the hospital --medical complex of the University. Required parking space will be separated into five areas, two of which can be enlarged to accompany future expansion of the facility.

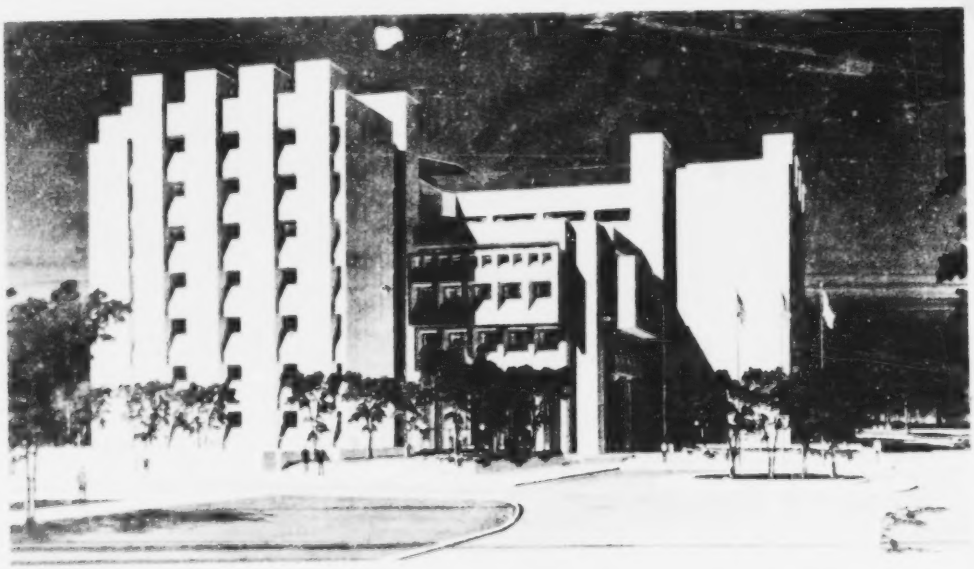

Figure 4. Architect's conception of new facility

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January, 1973

April, 1973

June, 1973

Figure 5. Progress of new construction

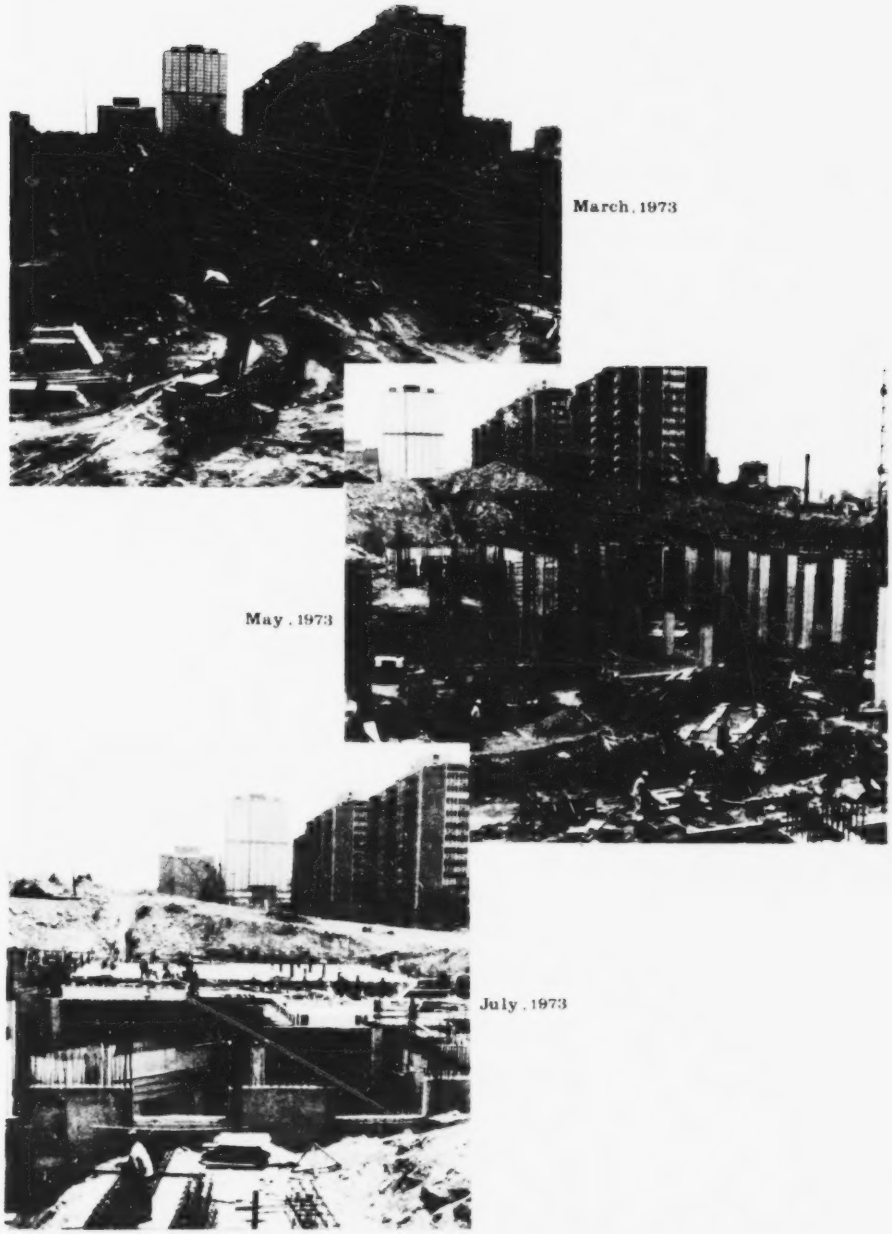

Figure 6. Progress of new construction

OIL AND HAZARDOUS MATERIALS SIMULATED ENVIRONMENTAL TEST TANK

The Edison Water Quality Research Laboratory (a division of NERC-Cincinnati) is currently constructing an oil and hazardous materials simulated environmental test tank (OHMSETT) on the south shore of Raritan Bay in Leonardo, N.J. This facility will provide an environmentally safe place for developing standard test procedures and for evaluating, under reproducible conditions, devices designed to contain and to pick up oil and hazardous materials spilled in rivers, harbors, and estuaries. In 1970, 3,334 oil spills (totaling about 15 million gal) and 376 hazardous material and other spills (totaling about a quarter of a million gallons) were tabulated. Of these 3,711 spills, 2,784 (involving 9.56 million gal) occurred in rivers and other inland waters, and in coastal bays, estuaries, sounds, ports, terminals, docks, beaches, and channels: that is to say, precisely in those environments whose conditions OHMSETT is designed to simulate. OHMSETT is large enough to test and evaluate prototype, full-sized devices, thus, any scale-up difficulties from lab and pilot-sized models can be caught here without having the environment suffer from misjudgments.

Tank Design

The test tank, which is 670 ft long, 65 ft wide, and 11 ft deep, is being constructed of reinforced concrete by Remsco Associates of Matawan, N.J. It was designed by Engineers, Inc., of Newark, N.J., for towing test equipment weighing up to 20 tons and for drawing up to 3 ft of water. One of the tank's long sides has a 14-ft wide roadway accessed by a ramp at the south end; the other has a 7-ft wide sidewalk. One short side will support a mechanically driven, flap-type wave generator capable of making 2-ft high waves with frequencies from 2.0 to 0.55 Hertz and with lengths up to 16 ft. Wave height will be selected before each test, and frequency may be varied to some extent during each test. Waves will either be absorbed by a "beach" at the opposite end of the tank, or (when the beach is dropped to the bottom) be reflected off the slightly V-shaped north end to generate the "confused sea" typical of a busy harbor or tide-ripped narrows (Figure 7).

Currents will be simulated by towing test equipment lengthwise down the tank with a 68-ft wide, 34-ton bridge that spans the tank and runs on rails. The bridge is pulled at speeds up to 6 knots by cables powered by two 500 hp electric motors located at the beach end of the tank. The bridge and wave generator will be controlled from a three-story, 18 ft by 25 ft control building to be located between the winch pad and the tank. The bridge will be used as a platform from which to disperse and recover test oil and hazardous materials, as well as for towing.

Special equipment for treating tank water is located near the control house. A 2,000-gpm pressure leaf, diatomaceous earth filter will clarify the 2.6 million gal of Raritan Bay water required to fill the tank to a depth of 8 ft. The same equipment, with the addition of a carbon filter aid, will treat water recirculated between tests to maintain the

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Figure 7. Oil and hazardous materials simulated environmental test tank

clarity required for photography and TV instant replay. Spent filter aid will be dewatered using a paper tape filter, and the spent filter aid and tape will be disposed of at an approved landfill site. When the tank must be emptied for maintenance purposes, the entire water volume will be treated until it meets all applicable State and Federal criteria before being returned to Raritan Bay (at a higher quality than when originally withdrawn). Additional specialized treatment equipment will be used whenever hazardous materials are used in tests.

The 40-ft by 50-ft preparation building for laboratory and shop equipment will parallel the west side of the tank, near the center. Analyses of tank water, oil, and hazardous materials will be performed in this building to determine whether they meet specifications for tests in the tank. The building will also house maintenance of the sensors, construction of the adapters necessary to mate them with the various items of equipment to be tested, and preparation of the equipment itself after it has been transported to the site. Some storage and office space will also be located there.

Data Collection

Data collected in tests at OHMSETT will be in the form of camera film, TV videotape, tape recorder tape, rolls of chart paper, IBM magnetic tape, and the conventional paper and pencil records common to laboratory analyses and field investigations. Some data reduction will be performed under contract, but the majority of the analysts and report writing will be conducted at the site or in the Edison Water Quality Research Laboratory.

Goals

The present goal is to develop as rapidly as possible standard tests and procedures to improve the quality and effectiveness of spill containment and cleanup devices. To this end, consultation with the Coast Guard, Navy, universities, and private and public parties has already been initiated. The aim is to make the tank fully productive just as soon as it becomes operational in early 1974.

To recapitulate, the chief purpose of the test tank is to ensure that if the test equipment fails for any reason to pick up or contain 100% of the test oil or hazardous material, these test fluids will be confined to the tank and not loosed on the environment.

RESOURCE RECOVERY VIA CPU-400: POWER FROM SOLID WASTE

The major resource recovery project being undertaken by the NERC-Cincinnati Solid Waste Research Laboratory (SWRL) involves a process that burns the combustible component of refuse and uses the hot gas stream to drive a turbine for the generation of electricity. The system, conceived to burn 400 tons of solid waste per day, has been designated as the CPU-400 by the contractor (Combustion Power Company of Menlo Park, Calif.).

The SWRL has pursued the development of this process over the past several years, and these efforts have resulted in a fully integrated, operational pilot plant. Over $6 million has been expended in the development of this process and pilot plant system.

Plant Design

The pilot plant model is a 100-ton per day unit consisting of a front-end solid waste separation system where incoming municipal refuse is shredded and air classified to remove noncombustibles (Figure 8). Metal and glass components are separated into categories suitable for recycling. The combustible fraction is transported pneumatically to a storage vessel that holds about 20 tons. From there, the shredded refuse passes into a weighing conveyor and then to the rotary airlock feeder valves, which deliver the solid waste fuel into the pressurized combustor. The turbine compressor supplies compressed air for transporting the solid waste fuel, for fluidizing the combustor sand bed, and for combustion air.

The hot gases from the fluidized-bed combustor pass through an alumina/sand separator and two stages of inertial separators to remove particulates. The cleaned, hot gases are then expanded through a gas turbine that will generate about 1,000 kw of electricity.

The pilot plant fluidized-bed combustor operates at a pressure of about 45 psig. The outside diameter of the combustor is almost 10 ft, the inside diameter is 7 ft, and the height is 22 ft. The external shell is made of mild steel, with refractory lining on the inside.

Future Outlook

The CPU-400 process is in the final stages of pilot plant development. Total system performance is being evaluated by a series of automatically controlled, long-duration test runs. The utility of this process for the combined energy conversion of sewage sludge and municipal solid waste to usable power is being scrutinized. The performance of the CPU-400 system under extended test conditions will very likely determine the role it is to play in solving two of the Nation's most pressing problems, the energy crisis and resource recovery.

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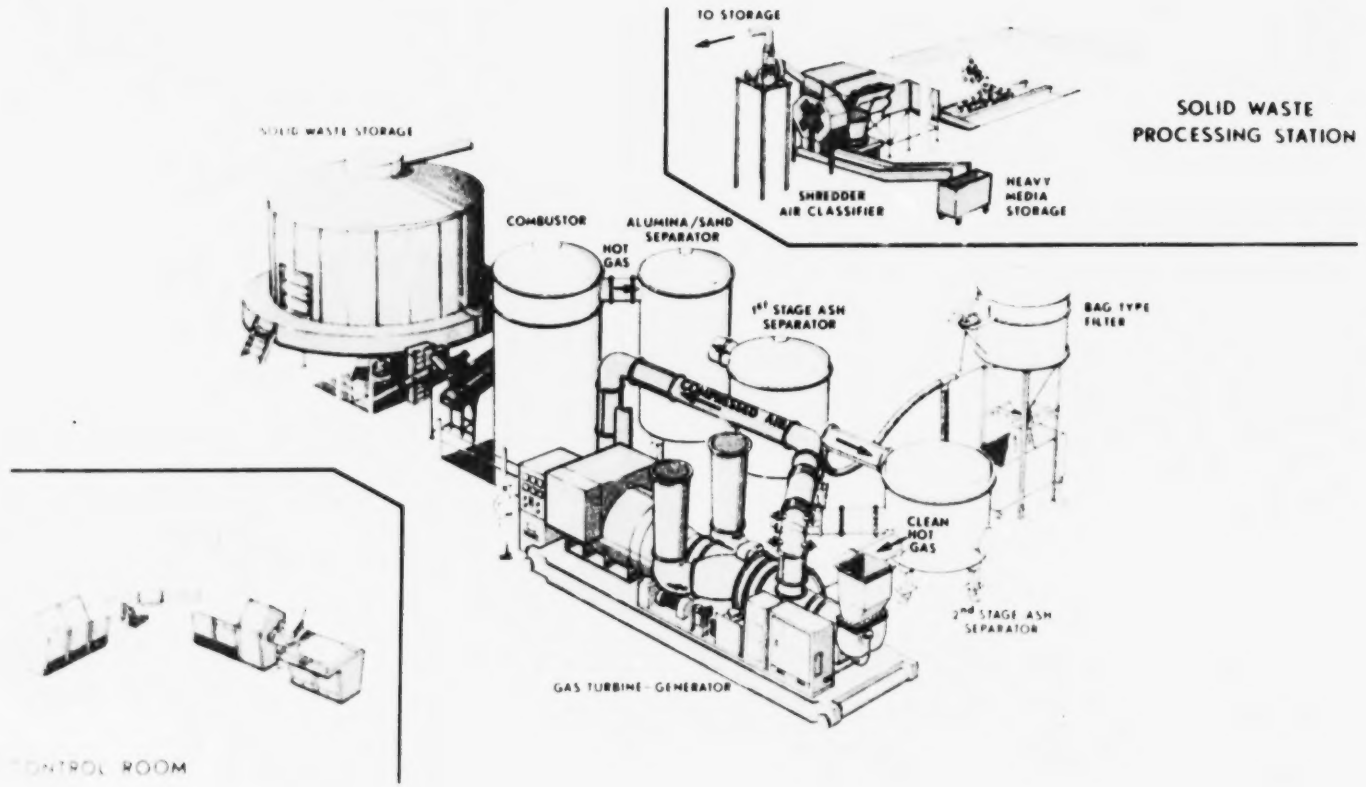

Figure 8. CPU-400 Pilot Plant

INTERNATIONAL ACTIVITIES

The Federal Environmental Research Programs in Cincinnati have for many years drawn thousands of foreign scientists to laboratories here. Conversely, many Cincinnati-based researchers have traveled abroad to participate in international seminars and to serve on technical committies in conjunction with a number of international agreements.

Since the inception of NERC-Cincinnati, these scientific exchanges have become increasingly important, and a number of official international agreements are being pursued with funds available under P.L. 480 and other programs set up to encourage worldwide cooperation in identifying and solving environmental problems.

International Organizations and Working Agreements

Committee on Challenges to Modern Society (CCMS)

This NATO committee coordinates environmental activities of NATO countries. International contacts and conferences between the United States Council of Environmental Quality and Great Britain's Department of Environment established plans for a joint effort in advanced wastewater treatment.

In September 1971, Mr. Francis M. Middleton, Deputy Director, NERC-Cincinnati, and Mr. Jesse M. Cohen, Chief, Physical-Chemical Treatment Section, AWTR Laboratory, met with British scientists in London to exchange information on the status of advanced waste treatment processes in the respective countries.

From these contacts, an agreement was reached under which Great Britain is developing advanced waste treatment systems and is constructing a $2 million physical-chemical treatment plant. Any NATO country may participate as copilot countries with the United States and Great Britain. Representatives of the German and French governments, who attended the initial CCMS meetings in London, are studying pure oxygen-activated sludge systems.

In November 1972, Mr. John J. Convery, Director of the NERC-Cincinnati Advanced Waste Treatment Research Laboratory, visited Brussels to attend the Plenary Session of the CCMS. In December 1972, a delegation from the United Kingdom including representatives of the Department of Environment from the Stevenage Laboratory, and consulting engineers who are designing the advanced waste treatment plant, visited the United States to observe a number of advanced waste treatment plants and to discuss treatment plant design problems.

US - USSR Bilateral Agreement

In July 1972, Mr. Convery visited the Soviet Union as part of a seven-man U.S. delegation. This delegation and their host counterparts discussed wastewater treatment technology in the USSR, as part of the information exchange provisions of the 1970 bilateral agreement between the US and USSR.

The delegates identified areas of mutual interest for possible further cooperation under the May 1972 accord signed by Presidents Nixon and Podgorny. The delegation met with a variety of Soviet groups concerned with wastewater treatment technology, industrial wastes, municipal wastes, water supply, water resources, and construction of treatment plants and irrigation works. The meeting convened in Moscow and visits were made to Leningrad, Kiev, and Siktivkar.

US - Japan Agreements

As a result of several bilateral agreements, the United States and Japan have established joint panels on environmental matters.

Following exchanges of visits during 1969-70, a joint committee on sewage treatment technology was established. In October 1971, Mr. Middleton headed a five-man team which visited Japan. In December 1972, a Japanese delegation visited Cincinnati and advanced waste treatment installations in California and Washington, D.C., and participated in a 3-day discussion with the Office of Air and Water Programs. They also visited NERC-Corvallis to discuss problems of eutrophication.

Other Overseas Visits

Organization for Economic Cooperation

Dr. Robert L. Bunch, Chief, Biological Treatment, AWTRL, has participated in meetings of the Organization for Economic Cooperation and Development, and has been an official United States representative of the Working Group on Detergents and Treatment Processes. This group is considering all aspects of the detergent problem, including their composition, health aspects of detergent additives, appropriate sewage treatment processes, treatability of detergent preparations in conventional processes, and the fate of particular consituents such as heavy metals and complex ions. The purpose of this effort is the development and dissemination of information concerning detergent preparations and associated environmental problems on the international scene.

Romania

At the request of the Romanian government, Mr. Jesse M. Cohen and Mr. Middleton visited Bucharest in September 1971 to discuss sewage treatment technology with Romanian authorities. Mechanisms were set up for exchange of literature and research results and the Romanian government was invited to make use of any of the advanced technology that has been developed in the OR&D research program.

World Health Organization

In December 1971, Mr. Middleton served on a panel on wastewater reuse sponsored by the World Health Organization (WHO) in Geneva, Switzerland. Mr. Middleton was responsible for completing the panel's report which will be published in a WHO series.

Technical Committee 147

Mr. Dwight G. Ballinger, Director, Analytical Quality Control Laboratory, headed the United States delegation to Technical Committee 147 - Water Supply of American National Standards, in Geneva, Switzerland, in April 1972. The committee is devoted to the development of analytical methods for water,

including characterization by physical, chemical, radiological, and microbiological measurements.

Great Lakes International Field Year

Mr. John A. Winter and Dr. Cornelius I. Weber, Analytical Quality Control Laboratory, participated in meetings of the study committees of the International Field Year for the Great Lakes (IFYGL) at Niagara Falls, Ontario, in November 1972. They reported on findings in the areas of interlaboratory chlorophyll reference samples, quality control measurements, and biological methodology employed by IFYGL labs, and a computerized system for IFYGL data in STORET.

Water Supply Meetings

Mr. Edwin E. Geldreich, NERC Water Supply Research Laboratory, attended a WHO conference in Ostend, Belgium, in March 1972, devoted to the development of health criteria guidelines for the WHO.

Dr. Norman A. Clarke and Mr. Donald Berman consulted with local officials in Buenos Aires, Argentina, and Sao Paulo, Brazil, concerning establishment of virology laboratories there. The Pan American Health Organization arranged this international technical assistance committee, which met in May 1972.

Mr. Gordon G. Robeck visited Singapore in March 1972 to serve as one of ten advisory panelists from the National Academy of Sciences at a workshop dealing with water resources in Singapore, Indonesia, Philippines, South Vietnam, and Thailand. Experts from Japan, France, and the United Kingdom also attended.

Mr. Robeck visited Lima, Peru, in August 1972 to participate in a symposium on water treatment methods sponsored by the Pan American Health Organization, and attended subsequent meetings on the same topic in Asuncion, Paragual, Rio de Janeiro, Brazil, and Buenos Aires, Argentina. The trip afforded a valuable opportunity to discuss vital problems of water supply with researchers, educators, and public officials from all over South America.

Poland

Dr. Andrew W. Breidenbach, Director, NERC-Cincinnati, visited Poland in January 1973 to act as a temporary adviser to the seminar "Design of Environmental Information Systems" sponsored by WHO in Katowice, and to consult with Polish officials regarding the P.L. 480 program.

Foreign Visitors

During the period covered by this report, NERC-Cincinnati was host to about 150 foreign visitors. These visitors came from many countries, with about half coming from Japan. The Cincinnati laboratory complex has been known throughout the world for many years, and many types of work being conducted here are of interest to foreign researchers. Historically, a large number of the visitors have come because of our activities in water pollution control, but much interest has been shown lately in solid waste, water supply, and other activities at NERC-Cincinnati.

Public Law 480 Projects

The Environmental Protection Agency is using funds available to the United States Government in various foreign countries under P.L. 480 to sponsor pollution control research projects in those countries. NERC-Cincinnati project officers are working with local research organizations in Poland, India, Israel, and Yugoslavia on several projects of mutual interest in the wastewater, water supply, air pollution, and solid waste areas. New projects are currently being developed in Poland and Tunisia. These cooperative efforts not only serve to advance the art of pollution control technology in all countries concerned, but also to promote the spread of information and a spirit of cooperation among environmental control researchers around the world.

A summary list of foreign projects involving NERC-Cincinnati scientists is listed below:

"Neutralization and Utilization of Post-Coagulation Sludge" Institute of Municipal Economy, Warszawa, Poland
(Investigator: J. Salbut - EPA Project Officer: R. L. Bunch)

A new treatment plant will produce drinking water from the Wista River by using alum coagulation. All available methods for dewatering alum sludge prior to its disposal will be evaluated, and an attempt will be made to find an economical way to recover alum for reuse in the plant. The Wista is similar to many major rivers in the United States in that it is both a receiving stream for wastewater and a source for drinking water.

"Utilization and Ultimate Disposal of Sludge from the Combined Treatment Plant/Sewage and Wastewater from Cotton, Linen, and Tannery Industry/Together with the Municipal Solid Wastes" Water Economy Research Institute, Wroclaw, Poland
(Investigator: H. Manczak - EPA Project Officer: R. B. Dean)

The treatment of sludges from industries and municipal sewage in the upper valley of the Bystrzyca River near the Czechoslovakian border will be investigated. All wastes are to be collected in order to protect a water reservoir on the river. An attempt will be made to compost industrial sludges with municipal sludges and solid waste to make them acceptable for landfill disposal and, if possible, to utilize them in agriculture. The same necessity for complete treatment and export of liquid wastes also exists in industrialized river basins in the United States.

"Development of Methods and Techniques for Final Treatment of Combined Municipal and Textile Wastewaters Including Sludge" Water Economy Research Institute, Katowice, Poland
(Investigator: J. Suschka - EPA Project Officer: R. B. Dean)

The United States and other countries are undergoing a change in the cloth and fibers being used. Cotton and wool are giving way to synthetic fibers in the textile industry, and new types of dyes are consequently also being introduced. Various combinations of wastewater treatment processes are being investigated to determine their effectiveness in treating a combination of domestic and textile wastewaters,

emphasizing the removal of color. The disposal of sludges generated by these processes is also being investigated.

"Solid Waste in India" Central Public Health Engineering Research Institute, Nagpur, India
(Investigator: A. D. Bhide - EPA Project Officer: L. W. Lefke)

A survey is being conducted of the present solid waste problems in India, with regard to the generation, storage, collection, processing, disposal or recycling of wastes generated in urban communities. The development of solid waste technology, as well as of non-technological systems depends on a complete understanding of the composition and properties of waste materials.

The information being obtained on composition and quantity of solid waste will be of value to Indian and United States researchers concerned with the proper management of solid residues.

"Health Effects of Nitrates in Drinking Water" Hebrew University, Jerusalem, Israel
(Investigator: H. Shuval - EPA Project Officer: L. J. McCabe)

Methemoglobinemia in infants (blue babies) is the cause of the concern for nitrates in drinking water. Surveys have now indicated that nitrates in water are not a public health problem in Israel because infants are not exposed to waters bearing significant nitrates. Epidemiological studies have therefore shifted to the Gaza Strip, where exposure is significant. Toxicological studies on rats have shown definite brain effects attributable to nitrate.

"Epidemiological Study of Methemoglobinemia in Croatia" Institute of Public Health in Croatia, Zagreb, Yugoslavia
(Investigator: B. Plese - EPA Project Officer: L. J. McCabe)

Surveys of several rural water supplies have been made and levels of nitrate and bacterial contamination have been determined. Three specific areas have been identified where 75% of the wells exceed the drinking water standard for nitrate and 87% show bacterial contamination. Case-control studies have begun in the town of Osijek, where 59 cases of methemoglobinemia have been reported since 1968.

"The Role of Silicates in the Etiopathogenesis of Endemic Nephropathy" Beograd University Medical School, Belgrade, Yugoslavia
(Investigator: A. Bata - EPA Project Officer: L. J. McCabe)

Endemic nephropathy is a serious kidney disease in some areas of the Balkans. The pattern of occurrence has suggested that water supply may play a role in its epidemiology. Silicates in drinking water are a possible cause of the disease. This hypothesis is being examined on this project.

"Physico-chemical Treatment of Combined Industrial-Municipal Wastewater and Sludge Utilization" Water Economy Research Institute, Katowice, Poland
(Investigator: J. Suschka - EPA Project Officer: H. S. Skovronek)

Combined industrial-municipal wastewater (primarily steel mill wastes) will be treated by physico-chemical methods on both laboratory and pilot plant scales.

Sludges available from current wastewater treatment operations, themselves a local enviornmental problem, are high in iron and should be useful as a coagulant for such treatment, as should the newly generated sludge. The extent to which the sludges must be dewatered and modified to make them suitable for this purpose, and the effectiveness of physico-chemical treatment, including multimedia filtration for this wastewater, will be established.

"Factors Influencing Lead Absorption from the Intestine" Institute for Medical Research, Zagreb, Yugoslavia (Investigator: K. Kostial - EPA Project Officer: J. F. Stara)

Various factors which might influence the absorption, metabolism, and toxicity of lead are being investigated. Special attention is given to lead absorption at the various physiological stages (young age, pregnancy, and lactation, and to the effect of selected dietary additives on the metabolism of the ingested lead (alginates, calcium, phosphorus, vitamin D, and milk)). Most of the experimental work is performed on rats using radioactive tracers such as lead 203 or 210 in the studies of lead metabolism, and calcium 45 or 47 in investigations of the comparative metabolism of calcium and lead. This work should provide a better understanding of lead metabolism and toxicity, particularly during the early stages of life, and of the methods which might be used to decrease lead absorption from the gut.

"The Detection and Inactivation of Enteric Viruses in Wastewater" Hebrew University, Jerusalem, Israel (Investigator: H. Shuval - EPA Project Officer: G. Berg)

The development of effective and economical procedures for inactivation by ozone of enteric viruses in wastewater, other polluted waters, and in renovated waters (with or without the aid of other disinfectants) is the subject of this grant. The chemistry of ozone and ozone species in polluted water is also being studied as it relates to ozone virucidal properties so as to optimize its application. Additional efforts are being devoted to a series of controlled comparative laboratory and field studies to develop and refine inexpensive methods for the quantitative detection of small amounts of viruses in large volumes of water.

"Indicators of Enteric Viruses in Waste and Other Waters" Technion-Israel Institute of Technology, Technion City, Haifa, Israel (Investigator: Y. Kott - EPA Project Officer: G. Berg)

The validity of fecal coliforms as indicators for the presence of viruses in various waters has been questioned because of the basic differences between viruses and bacteria in the relative numbers excreted, in the constancy of their excretion, and in their survival capability in the environment. Yet both viruses and fecal bacteria are from the same sources, and some useful virus indicator functions may be assignable to the fecal bacteria. Since it is expensive, time-consuming, and relatively difficult to recover viruses, a suitable indicator for viruses in all situations would be a valuable tool. The major thrust of this project is thus to determine the relative ratio that occurs among these organisms under a variety of treatment and natural conditions.

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